Banco de Portugal
EUROSYSTEM

Occasional Papers

1 | 2007

FINANCIAL SECTOR ASSESSMENT PROGRAMME PORTUGAL: BANKING SYSTEM STRESS-TESTING EXERCISE

Economics and Research Department

April 2007

Please address correspondence to
Economics and Research Department
Banco de Portugal, Av. Almirante Reis no. 71, 1150-012 Lisboa, Portugal;
Email: estudos@bportugal.pt

BANCO DE PORTUGAL

Economics and Research Department

Av. Almirante Reis, 71-6th floor

1150-012 Lisboa

www.bportugal.pt

Printed and distributed by

Administrative Services Department

Av. Almirante Reis, 71-2nd floor

1150-012 Lisboa

Number of copies printed

130 issues

Legal Deposit no. 257971/07

Table of contents

Executive summary

This paper summarizes the methodologies and findings of the banking system stress tests conducted in 2006 by Banco de Portugal in the context of the International Monetary Fund (IMF) Financial Sector Assessment Programme (FSAP).

- The core of the exercise was a top-down stress test of the banking system. This exercise allows assessing the impact of alternative full-fledged macroeconomic scenarios (a baseline scenario and two stress scenarios) on the consolidated accounts of the banking system.
- The top-down exercise was complemented with a bottom-up approach, where banks assessed the impact of the alternative macroeconomic scenarios on their individual financial statements. This approach has the advantage of providing a cross-check of the results of the top-down exercise and also allows capturing the heterogeneity among institutions. The bottom-up exercise also included a sensitivity analysis which consists in assessing the impact on assets, operating profits and regulatory capital of large and instantaneous shocks on risk factors, holding all other factors constant. Six banking groups, representing around 80 per cent of the Portuguese banking system (in terms of total assets as of December 2004) performed the bottom-up stress test exercise.

The stress test of the banking system was complemented with the estimation of the loss distribution of banks stemming from non-financial corporations' credit defaults. This extends the central projection of the stress test exercise by characterizing the whole distribution of losses for non-financial corporations. In addition, a study was undertaken on the interactions between the banking sector and the macroeconomy, aiming in particular to study the importance of feedback effects from the economy's financial side to aggregate macroeconomic variables.

Concerning the macroeconomic scenarios used in the exercise, which were designed at Banco de Portugal's Economics and Research Department, the baseline scenario is essentially an extension, up to 2008, of the macroeconomic projections conducted in the context of the Eurosystem December 2005 Broad Macroeconomic Projection Exercise, comprising a very moderate recovery of overall macroeconomic conditions over the 2006-2008 period. Notice that this projection was superseded by Banco de Portugal's forecasts for 2007 and 2008 published in the winter 2006 issue of Boletim Económico. The disruptive adjustment scenario assumes an abrupt adjustment of the global imbalances in early 2006. This adjustment is mainly characterized by a sharp deceleration in US economic activity that translates into a slowdown in overall worldwide economic activity. Moreover, there is a shift in portfolio preferences away from the dollar, leading to an appreciation of the euro vis-à-vis the US dollar and in effective terms. In addition, the sentiment in global equity markets deteriorates markedly, translating into a sharp decline in global stock prices. Finally, the ECB

is assumed to adjust its monetary policy and cut its intervention rates, reflecting the downward adjustment in inflation stemming from the appreciation of the euro, and the slowdown in economic activity. Finally, the cyclical asynchrony scenario consists in simulating the impact of an unexpected increase in productivity in the major euro area economies, which prompts higher domestic demand and imports in the euro area; that, however, does not spill over into higher Portuguese exports due to an assumed significant loss in export market shares. Moreover, oil prices are assumed to increase permanently throughout the projection horizon. A substantial stake of the impact of this stress scenario stems from the behaviour of the monetary policy authority. Indeed, the ECB is expected to adjust short-term interest rates upwards, in view of higher consumer price inflation due to the increase in oil prices, higher GDP growth rates in the euro area, and tighter labour market conditions. The cyclical asynchrony between Portugal and the euro area economy reflects the fact that in this scenario economic activity in Portugal actually falls, while the euro area economy starts growing at a much stronger pace.

The top-down stress test was based on the derivation of the impact of each scenario on the medium-term projection of financial statements (balance sheet and profit and loss statements) for the aggregate consolidated accounts of banking institutions. The results of the exercise suggest that the banking system is resilient to very unfavourable, but still plausible, macroeconomic scenarios, incorporating wide ranging sources of risk – both direct and indirect. All in all, it can be concluded that banks financial position is more sensitive to stock market risks than to credit risks, given that the strong decrease in credit quality in the cyclical asynchrony scenario (motivated by the interest rates increase in a context of negative growth in economic activity) has a smaller impact on profitability and solvency than the financial market disturbances, namely the sharp decline in stock prices featuring in the disruptive adjustment scenario.

In the bottom-up stress test banks were asked to translate the macroeconomic scenarios into their individual financial statements. An important input to the bottom-up exercise was the estimated default probabilities of non-financial corporations and households under the three macroeconomic scenarios. As to non-financial corporations, in general, larger loans are less likely to default. Given the high concentration of the banking system corporate loan portfolio in large exposures, this translates into a relatively favourable average probability of default. In what concerns households, the probability of default on housing loans is estimated to be much lower than on consumer and other purposes loans. As expected, the two stress scenarios yield much larger probabilities of default than the baseline.

The bottom-up stress-test exercise was divided into two parts. In the first part banks were asked to project their performance in terms of balance sheet value, operating profits and regulatory capital under the three macroeconomic scenarios, over a three-year period (scenario analysis). As expected, impacts vis-à-vis the starting point are very small in the baseline scenario. The disruptive adjustment stress scenario produces the strongest impacts of all scenarios, mostly as a result of market risk factors, which hinge on the valuation of the portfolios of banks and, in particular, on the employees' pension funds. Consequently, a strong shock on share prices would impact significantly the banks' performance. In the

cyclical asynchrony stress scenario, impacts are evenly distributed throughout the three-year projection horizon and are mostly associated with credit risk. This results from the fact that in this scenario negative GDP growth rates are coupled with a strong increase in interest rates while in the disruptive adjustment scenario, notwithstanding the negative growth of economic activity, the decline in interest rates mitigates credit risk. The different behaviour of interest rates, coming from different monetary policy responses, was also important in terms of the impact of the alternative scenarios on banks profitability. In general, the less unfavourable stress scenario for banks profitability is the cyclical asynchrony scenario. Although this scenario includes the highest probabilities of default, it also considers the largest increases on both short and long term rates, the latter having a favourable impact on the profitability of banks.

In the second part of the bottom-up exercise, banks were asked to perform a sensitivity analysis, that is, to report the effect of an immediate and instantaneous shock to one risk factor on the balance sheet value, operating profits and regulatory capital. Three risk factors were examined: interest rate risk (a parallel shift in the yield curve and a steepening or flattening of the yield curve), equity price risk and foreign exchange rate risk (euro/US Dollar). The results obtained suggest that the banks can absorb these individual shocks well. Equity price risk produces the strongest effects in relative terms.

The banks were also asked to perform sensitivity tests on the balance sheet of the banks employees' pension funds (defined-benefit schemes only). There is a strong sensitivity to the equity price shock and to a lesser extent to downward changes in the yield curve. The relatively strong sensitivity to downward changes in the yield curve results from the duration mismatches between pension funds assets and liabilities. Therefore, a lowering of interest rates has a negative effect on net asset values.

The bottom-up approach confirmed the main conclusions of the top-down stress-test, namely the greatest importance of equity risk, followed by credit risk. The remaining sources of risk proved to be of much less importance. Moreover, according to the bottom-up stress test results, all banking groups should present solvency ratios higher than 9 per cent throughout the projected horizon and under all scenarios.

Concerning the estimation of the loss distribution of banks stemming from non-financial corporations' credit defaults, the results confirm that the cyclical asynchrony stress scenario is more adverse than the disruptive adjustment case. This analytical instrument makes possible the analysis of specific percentiles of the capital adequacy ratio (CAR) distribution for the overall banking system. The results show that the system as a whole is resilient to extreme, but plausible, macroeconomic outcomes, impacting default rates of credit to non-financial corporations. For instance, the probability that the banking system's CAR falls below 9.9 per cent is 0.5 per cent.

All in all, the entire set of exercises confirms that the Portuguese banking system is resilient, even in the case of adverse and severe shocks. In situations of prolonged recessions, either because of the abrupt unwinding of macroeconomic global imbalances (disruptive adjustment scenario) or because of a persistent divergence with economic growth in the euro area

(cyclical asynchrony scenario), the Portuguese banking system should be able to continue to withhold adequate profitability and solvency levels.

The design and implementation of the stress tests performed under the Financial Sector Assessment Programme (FSAP) of the Portuguese financial system was a challenging experience.

On the one hand, it was an opportunity to thoroughly discuss and re-think the top-down stress test, which has been implemented internally since 2002. A large part of the model was fine-tuned and further enhanced. Furthermore, the modelling setup of the projections regarding the evolution of loan impairments and the associated provisions was carefully redesigned, in order to fully capture specific features resulting from the Portuguese regulatory framework. More generally, it provided an opportunity to sophisticate and expand the set of analytical tools.

On the other hand, the FSAP motivated the design and implementation of the first scenario-based bottom-up stress test of the Portuguese banking system. This exercise permitted a fruitful exchange of views between the Economics and Research Department and the Supervisory Department of Banco de Portugal, as well as with high level risk managers in the major Portuguese banking groups, in a spirit well in accordance with what is proposed in the Second Pillar of Basel II. Moreover, the exercise itself made it possible to understand the impact of shocks on each banking group, as well as to improve knowledge in what concerns the dispersion of those impacts.

The exercise underscored the importance of conducting stress tests based on multidimensional, plausible but particularly stressful scenarios that allow the identification of the sources of risks. The encompassing nature of the exercise is worth emphasising, namely the fact that it considered both direct and indirect risks, for instance risks arising from banks' employees pension funds. Even though this approach increases significantly the complexity and requirements of the exercise (most notably in what concerns the efforts required to participating banks), it allows for the proper identification of fragilities or sources of risk comprised in a wide range of banks' risk profiles.

The very good cooperation of banks, which was of paramount importance for the successful implementation of the exercise, should also be acknowledged.

1 Introduction

According to the IMF's Handbook on Financial Sector Assessment[1], the first pillar that constitutes the basis for the assessment in a FSAP is "Macroprudential surveillance and financial stability analysis by the authorities to monitor the impact of potential macroeconomic and institutional factors (both domestic and external) on the soundness (risks and vulnerabilities) and stability of financial systems". The financial stability analysis "encompasses (…) quantitative analysis of risks and vulnerabilities (…). The quantitative analysis typically involves monitoring at a suitable level of aggregation; analyzing the economic and institutional determinants for a range of financial soundness indicators of banks (FSIs) and examining the impact of various plausible, but exceptional, macroeconomic and institutional shocks on the financial soundness indicators. This type of monitoring and analysis of FSIs—referred to as macroprudential surveillance—includes testing stress levels of the system in response to plausible shocks, which helps identify the key sources of risks and the vulnerabilities to various risk factors".

This quote highlights the importance of stress tests in the context of a FSAP. It is thus crucial to root this analysis not only in state-of-the-art methodologies but also in the best practices identified in other countries.

This paper presents the main features of the banking system stress testing framework in the context of the FSAP of Portugal. The overall framework builds on the experience acquired by the Economics and Research Department of Banco de Portugal since 2002. This experience was the subject of detailed discussions during the first IMF visit in 6-20 December 2005. The core of the exercise was a top-down stress test of the banking system. This exercise allows assessing the impact of alternative full-fledged macroeconomic scenarios on the consolidated accounts of the banking sector. This exercise was complemented with a bottom-up approach, where the major banks assessed the impact of several scenarios on their individual balance sheets. The bottom-up exercise is useful not only to assess differences across institutions but also because it allows for a cross-checking with the top-down approach. The stress test was also complemented with additional exercises. One was the estimation of the loss distribution of banks stemming from non-financial corporations' credit defaults. This extends the stress-test exercise, where only a central projection is estimated, by characterizing the whole distribution of losses for non-financial corporations. A study of the interactions between the financial sector and the macroeconomy was also done. This study aimed, in particular, to analyse the importance of feedback effects from the economy's financial side to aggregate macroeconomic variables.

The exercise was carried out between September 2005 (preparatory work) and June 2006 (completion of internal reports).

The remainder of this paper presents the general framework underlying the four components of the stress test and also, in more detail, each of these components, including an overview

1 IMF (2005), Financial Sector Assessment – A Handbook, September.

of the results. The next section describes the macroeconomic scenarios. Section 3 describes the top-down approach. Section 4 briefly presents the methodology for the default probabilities estimation, and the bottom-up exercise. Section 5 contains an analysis of the dispersion of losses from exposures to non financial corporations and a box on the interactions between the banking sector and the macroeconomy.

2 Macroeconomic Scenarios

This section describes the general framework underlying the whole FSAP exercise. As for the construction of the macroeconomic scenarios, there are three issues that should be highlighted:

- First, the alternative scenarios considered in the exercise are general equilibrium scenarios, where all macroeconomic variables move in response to a specific set of shocks that must be supported by a consistent underlying economic story. This procedure disciplines the exercise in terms of macroeconomic reasoning and probabilistic analysis. Further, it is in line with the quantitative risk analysis that is currently undertaken alongside Banco de Portugal's projections.
- Second, in what concerns the behaviour of the monetary authority, the stress tests assume that the central bank follows a Taylor rule. As for the fiscal authority, it is assumed that the government implements the necessary set of measures in order to ensure the fulfilment of the provisions of the Stability and Growth Pact.
- Third, the time horizon for the simulations comprises three years (2006-2008). As the exercise does not consider feedback reactions of banks, the time horizon should not be too long. This also corresponds to the horizon set in the Stability Programme for the Portuguese Government to comply with the 3 per cent fiscal deficit threshold.

Under this framework, three macroeconomic scenarios were constructed at the Economics and Research Department of Banco de Portugal. The baseline scenario is essentially an extension, up to 2008, of the macroeconomic projections estimated in the context of the Eurosystem December 2005 Broad Macroeconomic Projection Exercise, comprising a very moderate recovery of overall macroeconomic conditions over the 2006-2008 period. This projection was superseded by Banco de Portugal's forecasts for 2007 and 2008 published in the winter of 2006 issue of Boletim Económico. Additionally, two stress scenarios were constructed: the disruptive adjustment scenario (also called stress scenario 1) and the cyclical asynchrony scenario (also called stress scenario 2). The disruptive adjustment scenario assumes an abrupt adjustment of the global imbalances in early 2006. This adjustment is mainly characterized by a sharp deceleration in US economic activity that translates into a slowdown in overall worldwide economic activity. The cyclical asynchrony scenario consists in simulating the impact of an unexpected increase in productivity in the major euro area economies that translates into higher domestic demand and imports in the euro area, which, however, do not spill over into higher Portuguese exports due to an assumed significant loss in export market shares.

This section describes in detail the three macroeconomic scenarios designed for the stress-test exercise. The description of the main assumptions of the macroeconomic scenarios, including the main fiscal assumptions for Portugal, is followed by a detailed description of the evolution of the main macroeconomic variables for Portugal in each scenario.

2.1 Main assumptions of the macroeconomic scenarios

2.1.1 Baseline scenario

The baseline scenario is essentially based on the macroeconomic projections elaborated by Banco de Portugal in the context of the Eurosystem December 2005 Broad Macroeconomic Projection Exercise (December 2005 BMPE, henceforth). These projections were extended forward until 2008 by extrapolating the common external assumptions and the underlying public finance assumptions. This projection was superseded by later forecasts from Banco de Portugal.

In comparison with the December 2005 BMPE, the current baseline scenario includes some changes, namely: (i) short-term interest rates evolve in line with a Taylor rule instead of remaining unchanged throughout the projection horizon; (ii) external demand for Portuguese exports is assumed to grow in 2008 at the same pace projected for 2007; (iii) bilateral exchange rates are assumed to remain unchanged also in 2008 at the levels prevailing in mid-December of 2005; and (iv) oil prices in US dollars in 2008 are assumed to remain unchanged at the average level implicit in the futures' markets for 2007.

The Taylor rule used in the exercise was defined as follows:

$$i_t = i^* + 1.5(\pi_t - \pi^*) + 0.8(y_t - \overline{y}_t)$$

where π_t, π^*, $(y_t - \overline{y}_t)$, i^*, and i_t represent, respectively, observed and target inflation rates, the output-gap, the equilibrium interest rate and the Taylor's rule interest rate for the euro area. The target inflation rate (π^*) was set at 1.9 per cent and the equilibrium interest rate (i^*) was set at 3.3 per cent[2] in the current exercise.

In the baseline scenario, the Taylor rule delivers a gradual, though marginal, increase in short-term interest rates throughout the projection horizon (see Table 2.1).

2 The equilibrium interest rate was calibrated to match the observed average interest rate in 2005. This procedure corresponds to using the first difference of the Taylor rule instead of its level.

Table 2.1

Euro area baseline and alternative stress scenarios. Annual averages.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Baseline										
Short-term interest rate	3.0	4.4	4.3	3.3	2.3	2.1	2.2	2.2	2.3	2.4
Long-term interest rate	4.7	5.5	5.2	5.0	4.2	4.1	3.5	3.6	3.7	3.7
Inflation rate	1.1	2.1	2.3	2.3	2.0	2.0	2.2	2.0	2.0	2.0
GDP growth rate	2.8	3.5	1.4	0.8	0.7	1.8	1.4	1.9	1.9	2.0
Output-gap	-0.7	1.1	0.7	-0.3	-1.4	-1.4	-1.8	-1.6	-1.6	-1.4
Disruptive adjustment										
Short-term interest rate	3.0	4.4	4.3	3.3	2.3	2.1	2.2	1.0	0.8	0.9
Long-term interest rate	4.7	5.5	5.2	5.0	4.2	4.1	3.5	3.4	3.3	3.3
Inflation rate	1.1	2.1	2.3	2.3	2.0	2.0	2.2	1.7	1.8	1.9
GDP growth rate	2.8	3.5	1.4	0.8	0.7	1.8	1.4	0.6	0.6	1.1
Output-gap	-0.7	1.1	0.7	-0.3	-1.4	-1.4	-1.8	-2.6	-3.1	-3.1
Cyclical asynchrony										
Short-term interest rate	3.0	4.4	4.3	3.3	2.3	2.1	2.2	3.6	4.2	4.9
Long-term interest rate	4.7	5.5	5.2	5.0	4.2	4.1	3.5	4.2	4.5	4.8
Inflation rate	1.1	2.1	2.3	2.3	2.0	2.0	2.2	2.5	2.5	2.4
GDP growth rate	2.8	3.5	1.4	0.8	0.7	1.8	1.4	2.8	2.8	2.9
Output-gap	-0.7	1.1	0.7	-0.3	-1.4	-1.4	-1.8	-0.9	-0.2	0.3

2.1.2 Stress scenarios

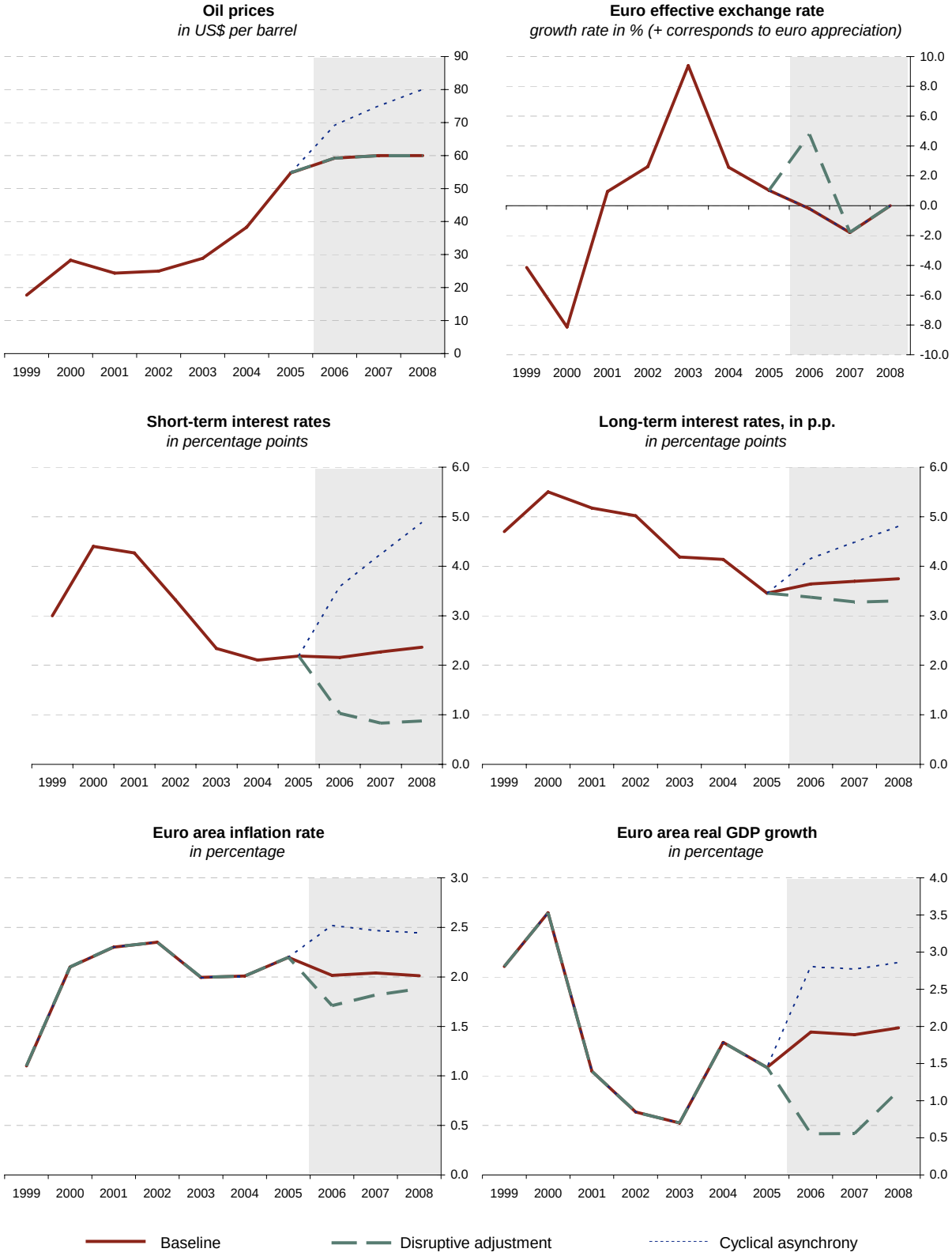
In the current stress-testing exercise, two stress scenarios were drawn:

- the disruptive adjustment scenario;
- the cyclical asynchrony scenario.

The behaviour of some of the variables included in the scenarios is displayed in Figure 2.1.

Figure 2.1

Characterization of the baseline and alternative stress scenarios.



2.1.2.1 Disruptive adjustment scenario

The disruptive adjustment scenario assumes an abrupt adjustment of the global imbalances in early 2006. This adjustment is mainly characterized by:

(i) a sudden decline in the demand for US assets and the abandonment of the existing pegs to the US dollar;

(ii) a shift in portfolio preferences away from the dollar, leading to a 18.3 per cent appreciation of the euro vis-à-vis the US dollar that corresponds to a 4.8 per cent appreciation of the euro in effective terms;

(iii) a sharp increase in the US long-term interest rates, not only due to a shift in the demand for assets issued in other currencies, but also to an increase in global market risk, inducing counterbalancing effects on euro area long-term interest rates;

(iv) a sharp deceleration in US domestic demand and economic activity that will translate into a deceleration in US imports, corresponding to a slowdown in exports in the rest of the world and in overall worldwide economic activity;

(v) a marked deterioration of the sentiment in global equity markets in view of a downward revision in companies' profit outlook. Accordingly, a 30 percent decline in global stock prices occurs in 2006, an event whose magnitude was calibrated to correspond to the maximum decline observed over any consecutive 22 business days since 1980 (See Box 1).

According to the available estimates, a downward adjustment in the US real GDP growth rate of 4 percentage points (p.p.) in 2006 and 1 p.p. in 2007, along with the impacts of the above mentioned exchange rate and long-term interest rate risk premium behaviour, would lead to a downward adjustment in the euro area GDP of around 1.5 p.p. both in 2006 and 2007 and 0.9 p.p. in 2008, assuming that the ECB adjusts its monetary policy in line with the previously presented Taylor rule. In this scenario, the short-term interest rate in the euro area would decline to a level around 1 per cent, reflecting the slowdown in economic activity and the downward adjustment in inflation stemming from the substantial appreciation of the euro vis-à-vis the US dollar.

The disruptive adjustment scenario previously described would materialize in the following impacts in the external environment for the Portuguese economy:

(i) a 25 per cent depreciation of the US dollar that translates into an appreciation of the Portuguese effective exchange rate of around 1.5 per cent;

(ii) a downward adjustment in the short-term interest rate of around 1.0 p.p., in line with the ECB monetary policy rule described by the Taylor rule;

(iii) a broad stabilization of the long-term interest rate, reflecting the counterbalancing effects of increased demand for euro assets and increased global uncertainty;

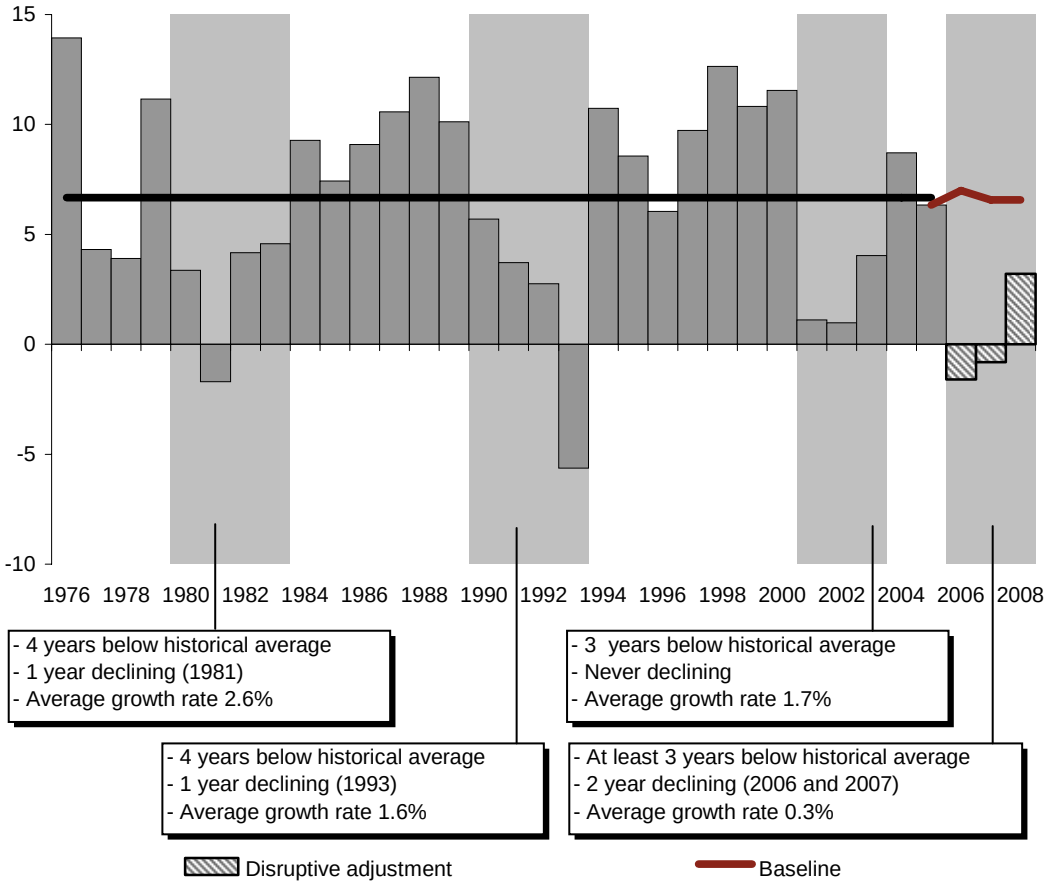
(iv) a downward adjustment in the external demand for Portuguese exports of 6.5 p.p. in 2006, 5.6 p.p. in 2007 and 2.6 p.p. in 2008, reflecting not only the slowdown in economic activity in the US and outside the euro area, but also the estimated spill over effects of this slowdown in the euro area economy (see Figure 2.2);

(v) an additional downward adjustment in the exports growth rate of 0.5 p.p. in each year, reflecting the impact of increased international competition;

(vi) nominal house prices are assumed to remain stable in this scenario, given that there is no evidence in favour of house prices overvaluation[3].

Figure 2.2

External demand for Portuguese manufactured goods. Growth rates, in percentage.



3 See, for instance, "Box 6.1 House prices in Portugal and macroeconomic fundamentals: evidence from quantile regression" in the 2005 Financial Stability Report of Banco de Portugal.

2.1.2.2 Cyclical asynchrony scenario

The cyclical asynchrony scenario consists in simulating the impact of an unexpected increase in productivity in the major euro area economies that translates into higher domestic demand and imports in the euro area, which, however, do not spill over into higher Portuguese exports. Therefore, this scenario incorporates substantial revealed market share losses of Portuguese exports.

The unexpected increase in euro area productivity boosts consumption and investment, reflecting an increase in households' expected permanent income and an increase in firms' capital rate of return. In contrast, in this scenario, global macroeconomic imbalances do not unwind and oil prices are assumed to increase permanently along the projection horizon, due to an increased global demand in the context of the prevailing oil refining capacity constraints.

The impact of this shock materializes in higher GDP growth rates in the euro area and higher consumer price inflation rates due to the increase in oil prices and tighter labour market conditions. In this context, the ECB is expected to adjust short-term interest rates upwards by 1.4 p.p., 0.6 p.p. and 0.7 p.p. in 2006, 2007 and 2008, respectively (2.7 p.p. in cumulative terms).

A substantial stake of the impact of this stress scenario stems from this behaviour of the monetary policy authority. In this scenario, the risks for price stability stem mainly from the level shift in oil prices that is concentrated in 2006. The acceleration of economic activity in the euro area is driven by a series of permanent supply shocks and by the subsequent demand pressures associated with higher permanent growth. These factors are not likely to induce inflationary pressures. However, the acceleration of activity allows the ECB to decrease the degree of monetary accommodation rapidly, moving to more neutral rates as the output gap closes. Given the increase in trend productivity embedded in this scenario, long-term neutral interest rates are considered to lie around 4.5 per cent[4]. The 1.4 p.p. average increase in short term interest rates in 2006 (from 2.2 in 2005 to 3.6 per cent in 2006) actually underestimates the sharp and frontloaded movement in these rates during 2006.

The cyclical asynchrony between Portugal and the euro area economy also arises from the fact that the increase in imports in Portugal's main trading partners does not translate into a higher level of exports of Portuguese tradable goods, determining substantial revealed market share losses. Thus, in this scenario economic activity in Portugal actually falls, while euro area economy starts growing at a much stronger pace.

The effect of this scenario for the Portuguese economy is mainly driven by the following set of factors that change the Portuguese economy's external environment:

4 In this scenario, it was assumed that equilibrium real interest rates rise gradually throughout the projection horizon, in line with perceived productivity growth. This would correspond, for example, to a situation where the ECB computes potential output using HP filtering techniques.

(i) an upward adjustment in oil prices from the baseline level of 60 US dollars per barrel to 70, 75 and 80 US dollars in 2006, 2007 and 2008, respectively;

(ii) an upward adjustment in short-term interest rates of 1.4 p.p., 0.6 p.p. and 0.7 p.p. in 2006, 2007 and 2008, respectively (2.7 p.p. in cumulative terms);

(iii) a downward adjustment in revealed markets share losses for the Portuguese economy by 3 p.p. in each year;

(iv) nominal house prices are assumed to decrease very slightly in this scenario throughout the projection horizon (given the strong increase in interest rates, housing demand should be relatively subdued, hence exerting some downward pressure on house prices).

2.2 Main fiscal assumptions for Portugal

The fiscal projections underlying the baseline scenario include the expected effects of budgetary policy measures that have already passed the legislative process or which are specified with sufficient detail in line with the rules of the Eurosystem BMPE.

In order to fulfil the deficit targets for 2006 and 2007 set in the stability programme and to reach a 3 per cent deficit in 2008, in a context of two very challenging macroeconomic scenarios for the Portuguese economy, additional fiscal consolidation measures had to be considered. These ones comprise, in particular, the impact of the reform of public administration, additional increases in indirect taxation and some restraint in the update of the civil servants wage scale and pensions.

2.3 Macroeconomic scenarios for Portugal

The baseline scenario comprises a very moderate recovery of overall economic activity over the 2006-2008 period, where GDP is expected to increase 0.8, 1.0 and 1.3 per cent respectively in 2006, 2007 and 2008 (see Table 2.2 and Figure 2.3). The unemployment rate is expected to remain stable throughout the projection horizon. The inflation rate is foreseen to level off at 2.2 per cent in 2007-2008 following the temporary hike projected for 2006, when a 2.6 per cent inflation rate is projected. The net external borrowing requirements for the Portuguese economy, as measured by the joint current plus capital account deficit is projected to remain in the range of 8.5-9.0 per cent of GDP for 2006-2008 period. No improvement is envisaged in this front in spite of some recovery in exports, due to the expected evolution in the income balance and in public transfers. Interest rates are assumed to remain relatively stable throughout the projection horizon.

The disruptive adjustment scenario triggers an impressive impact on overall economic activity mainly due to the significant downward adjustment in external demand, in contrast with the baseline scenario where the boost in exports supports the mild economic recovery. Furthermore, there is an assumed additional reduction of 0.5 p.p. in the growth rate of exports, reflecting the impact of increased international competition. This scenario entails a

decline in economic activity in 2006 and 2007 in Portugal, followed by a virtually nil growth rate in 2008, corresponding to a cumulative loss of 4.9 per cent in real GDP vis-à-vis the baseline level. Therefore, the unemployment rate rises steadily along the projection horizon, standing above the baseline projection in 2008. In spite of the sharp downward adjustment in exports stemming from the decline in external demand, the joint current and capital account deficit is expected to present an improvement, although to some extent temporary, due to the significant downward adjustment in imports following the impressive reduction in overall demand. In particular, private consumption is affected by the additional increases in indirect taxes and in the price of publicly provided services, and the freezing of pensions and civil servants' wages. Notwithstanding the appreciation of the Portuguese effective exchange rate, inflation is expected to increase both in 2006 and 2007 vis-à-vis the baseline scenario, due to the fiscal measures required to comply with the Stability Programme. However, in 2008 inflation is expected to reach 1.4 per cent, almost a 1 p.p. below the baseline figure.

The cyclical asynchrony scenario leads to a downward adjustment in output growth in the range of 1.0-1.5 p.p. per year over the exercise horizon vis-à-vis the baseline. GDP declines in the three years of the projection horizon, corresponding to a cumulative loss of 4.1 per cent vis-à-vis the baseline level. Nevertheless, the recession observed in this scenario is more moderate than in the disruptive adjustment scenario. This slowdown stems essentially from the increase in the short-term interest rates following higher GDP growth in the euro area, though the permanent higher oil prices also play some role. GFCF and private consumption are the two GDP components most affected by the interest rates' hike. In particular, private consumption is now more severely affected than in the previous scenario, recording historically unprecedented negative growth rates. These reflect the impact of the fiscal measures together with the increase in interest rates in the context of the high households' indebtedness level. In turn, the increased external demand does not translate into a pickup in exports, since a 3 per cent market share loss in each year is assumed vis-à-vis the baseline. The unemployment rate is projected to increase gradually above the level of the baseline scenario, standing above the baseline value in 2008. Inflation is envisaged to increase, reaching a peak of 3.6 per cent in 2007 and reverting to 2.8 per cent in 2008. This increase in the inflation rate follows mainly from the effects of additional fiscal policy measures required to comply with the 3 per cent deficit in 2008, though the oil prices increase also adds to this feature. The joint current and capital account deficit is expected to present a slight improvement in 2007 and 2008 mainly due to the significant downward impact on imports, following the sluggish development in both GFCF and private consumption.

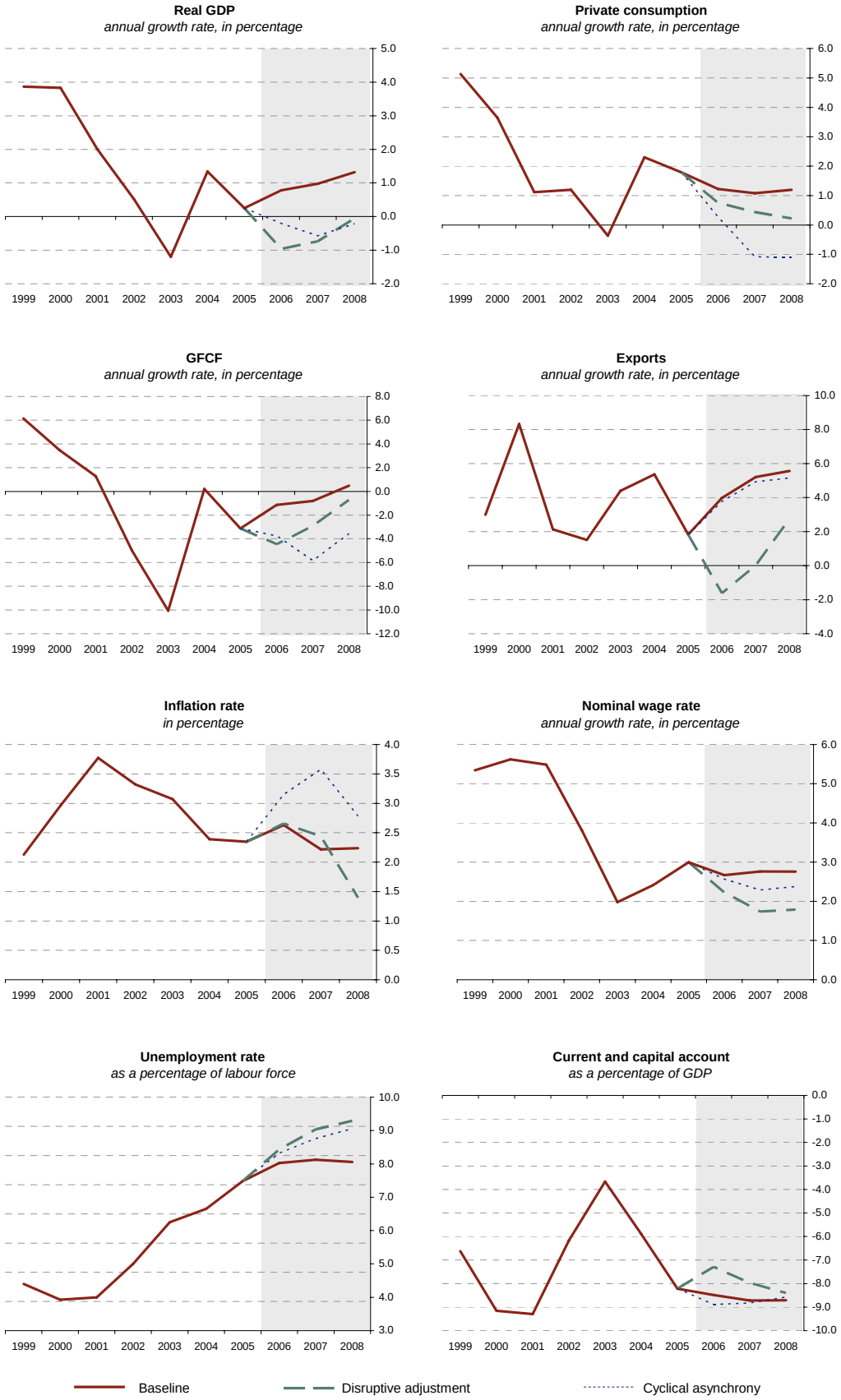
Table 2.2

Baseline and alternative stress scenarios.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GDP										
Baseline	3.9	3.8	2.0	0.5	-1.2	1.3	0.3	0.8	1.0	1.3
Disruptive adjustment								-1.0	-0.7	-0.1
Cyclical asynchrony								-0.2	-0.6	-0.2
Private consumption										
Baseline	5.1	3.6	1.1	1.2	-0.4	2.3	1.8	1.2	1.1	1.2
Disruptive adjustment								0.8	0.4	0.2
Cyclical asynchrony								0.3	-1.1	-1.1
Government consumption										
Baseline	6.0	3.5	3.5	1.7	-0.1	2.6	1.1	0.7	0.4	0.4
Disruptive adjustment								-1.1	-0.5	-0.2
Cyclical asynchrony								-1.1	-0.5	-0.1
GFCF										
Baseline	6.2	3.5	1.3	-5.0	-10.1	0.2	-3.1	-1.1	-0.8	0.5
Disruptive adjustment								-4.5	-2.9	-0.7
Cyclical asynchrony								-3.8	-5.8	-3.6
of which:										
Public GFCF										
Baseline	9.6	-7.2	8.5	-5.4	-2.2	-6.0	-6.5	0.6	-3.9	0.8
Disruptive adjustment								-3.1	-8.7	-1.6
Cyclical asynchrony								-3.9	-9.4	-2.1
Business GFCF										
Baseline	7.9	6.7	1.6	-6.0	-8.4	2.1	-3.2	-0.9	-0.5	0.3
Disruptive adjustment								-4.9	-2.0	-0.5
Cyclical asynchrony								-2.9	-6.0	-4.6
Exports										
Baseline	3.0	8.3	2.1	1.5	4.4	5.4	1.8	4.0	5.2	5.6
Disruptive adjustment								-1.6	0.0	2.8
Cyclical asynchrony								3.8	4.9	5.2
Imports										
Baseline	8.7	5.3	1.3	-0.5	-0.7	6.8	2.4	2.8	3.2	3.5
Disruptive adjustment								-0.6	1.0	2.2
Cyclical asynchrony								1.1	0.1	1.0
Consumer price inflation										
Baseline	2.1	3.0	3.8	3.3	3.1	2.4	2.3	2.6	2.2	2.2
Disruptive adjustment								2.7	2.4	1.4
Cyclical asynchrony								3.2	3.6	2.8
Households real disposable income										
Baseline	5.2	4.3	2.1	0.8	-0.7	1.4	1.8	0.3	1.4	1.4
Disruptive adjustment								0.2	-0.3	0.4
Cyclical asynchrony								-1.0	-0.9	-0.3
Household saving rate (as a % of disposable income)										
Baseline	9.0	9.5	10.7	10.4	10.5	9.6	9.7	8.8	9.1	9.3
Disruptive adjustment								9.2	8.5	8.7
Cyclical asynchrony								8.5	8.7	9.5
Current and capital account (as a % of GDP)										
Baseline	-6.6	-9.2	-9.3	-6.2	-3.7	-5.9	-8.2	-8.5	-8.7	-8.7
Disruptive adjustment								-7.3	-8.0	-8.4
Cyclical asynchrony								-8.9	-8.8	-8.6

Figure 2.3

Macroeconomic variables in the baseline and alternative scenarios.



3 Top-Down Stress Test

The core of the stress test is based on the exercise carried out internally since 2002 in the Economics and Research Department of Banco de Portugal. Based on the macroeconomic scenarios for the Portuguese economy, the impact of each scenario on the medium-term projection of financial statements (balance sheet and profit and loss statements) for the aggregate consolidated accounts of banking institutions is derived.

As mentioned above, the ultimate goal is to assess the impact of the stress scenarios on the banks' performance. There are four issues that should be highlighted:

- First, the scope of the analysis focused on the banking sector, more specifically on the financial institutions that are under the supervision of Banco de Portugal. Therefore, the analysis excluded the insurance sector[5] (except for the indirect effect on banking groups' profit and loss accounts).
- Second, the top-down exercise considers two main sources of risk in banks' portfolios: market and credit risk. Market risk was taken into account both in banks' own portfolio and in their employees' defined-benefit pension funds. The modelling of credit risk has received special attention. In fact, credit stands for the majority of banks' assets, thus accounting for a significant share of bank's potential balance sheet losses. Further, credit risk has an important cyclical component and it has been frequently the cause of problems in several banking systems.
- Third, translating the macroeconomic scenarios into aggregate consolidated accounts of banking institutions requires estimating a number of time series equations. The stress test procedure embodies equations for the following variables: (i) credit to households; (ii) credit to non-financial corporations; (iii) deposits of the non-financial private sector (broken-down into households and non-financial corporations); (iv) non-performing loans; (v) specific provisions.
- Fourth, since this approach does not explicitly include feedback effects (i.e., banks' reaction to shocks), the time horizon of the exercise should not be longer than 3 years. This is actually consistent with the time horizon set in the Stability Programme for the Portuguese Government to comply with the 3 per cent deficit threshold. The longer the time horizon, the more important it is to incorporate some type of reaction of financial institutions in terms of their balance sheet decisions. Finally, it should also be noted that there is no detailed analysis of the propagation of shocks across individual institutions. Nevertheless, such propagation should be almost negligible, taking into account the limited exposures, in relative terms, in domestic interbank markets.

5 In the context of the Financial Stability Assessment Program, both a top-down and a bottom-up stress test were performed for the insurance sector by Instituto de Seguros de Portugal. Moreover, one institution was considered as a conglomerate in the banking system bottom-up stress test exercise. In this case, considering both the banking and the insurance segments of the banking group were included (see section 4.2).

3.1 Overview of the exercise

The main analytical focus of the scenario-based exercise is on the quantification of future default intensity on the loan portfolio, at historically very low levels in 2006, and the consequent impact on the overall profitability and capital adequacy of banks. This exercise highlights two sources of risk: market risk and credit risk. Equity risk in the securities portfolio, including the portfolios of the banks' employees defined benefit pension funds, was taken into account, namely the quantification of losses in a context of a global decline in equity prices. Further, a special attention was given to credit risk because this type of risk has a cyclical nature and its materialisation caused severe systemically important crises in banking systems at the international level.

The top down stress test exercise has been undertaken in Banco de Portugal since 2002 for the aggregate of the banking system. In general, the basic idea underlying the exercise is to model the whole Balance Sheet, Profit and Loss account and some regulatory aggregates, such as, provisions and capital adequacy, for the total banking system in a way consistent with macro-economic scenarios. However, in 2005, only 13 banking groups, representing 87 percent of total assets in December 2004, adopted the International Accounting Standards. Therefore, due to data availability constraints, the current exercise does not consider the total banking system but this smaller (although very representative) group of banks.

Table 3.1 presents the assumptions underlying the estimates of banks' balance sheet items. The loan portfolio and deposits from customers (both broken-down into households and non-financial corporations) were projected using econometric models. Particular care was given to the consistency between, on the one hand, credit and deposit developments and, on the other, the projection of domestic demand, such as investment and consumption, as well as private saving. Household and non-financial corporations' credit was also modelled. The securities portfolio was projected by accumulating net acquisitions of securities consistent with nominal GDP growth and estimated value changes. The accumulation of sundry accounts such as "Other assets" and "Other liabilities" was made consistent with nominal GDP growth, while capital and reserves accumulate with retained earnings (with a 50 percent pay-out ratio) and reflect, through the change in reserves, changes in market value in the available-for-sale securities portfolio. Gross interbank assets were set at the December 2005 level, while gross market financing, which comprises interbank liabilities, issued securities and subordinated debt, is the balance sheet slack variable.

Table 3.1

Assumptions underlying balance sheet items.

Assets		Liability and capital accounts	
Item	**Assumptions**	**Item**	**Assumptions**
Interbank assets	Set at the last known value (Dec. 2005).	Interbank liabilities	These three items correspond to bank's market financing when taken in conjunction. This is the balance sheet's slack variable. In the event market financing decreases, the reduction is imputed to interbank liabilities. Otherwise, additional funding needs are accommodated in securities' issuance. Subordinated debt is kept constant.
Credit to customers	Gross loans to households and non-financial corporations were projected according to models. Deduction of impairment is performed in line with specific provisions projections according to model results.	Securities issued	
Securities (includes investment in subsidiaries and associates book by the equity method)	Net acquisitions consistent with nominal GDP growth. Deduction of value changes: in 2006 a 30 per cent decline in stock prices was considered in the *Disruptive adjustment scenario*; estimations of fixed-income value changes considered according to each scenario.	Subordinated debt	
		Funding from customers	Projected according to model for deposits of the non-financial private sector. An additional model projects the share of demand deposits for the purpose of simulating net interest income.
Non-financial assets	No transactions after Dec. 2005. Depreciations at a constant rate.	Other liabilities	Projected according to nominal GDP growth.
Other assets	Evolve according to nominal GDP growth.	Capital and reserves	Accumulate retained earnings (50% pay-out if positive). Available for sale and investment in associates' value changes are reflected in changes in reserves.

The main assumptions underlying the projection of the profit and loss account are presented in Table 3.2. In sum, the profit and loss account was projected as follows:

- Net impairment charge-off follows a model for specific provisions;
- Net interest income is endogenous, reflecting the product of average implicit interest rates and average outstanding amounts of interest bearing assets and liabilities, broken-down by major categories. Impaired loans do not accrue interest;
- Stock market sensitive P&L items (commission income, gains on financial operations, income from securities and income from associates) are very difficult to model, given their inherent volatility. As such, after scaling them by average total assets, the following procedure was applied:
  - In the ***baseline scenario*** they were set at average levels over the 1999-2005 period (as a percentage of average total assets), except income from associates, set at the 2005 level;
  - In the ***disruptive adjustment scenario in 2006,*** commission income, income from securities and income from associates were set at 1.64 standard deviations away from the mean in the 1999-2005 period

(percentile 5 of a normal distribution with mean and standard deviation equal to those observed during this period for each time series). Gains on financial operations were set at the minimum level in the same period, observed in 2002. Afterwards, these items converged linearly to the baseline level in 2008;

- In the ***cyclical asynchrony scenario***, these variables are simple averages of the other two scenarios;
- Gains on financial operations were further shocked with estimated losses in share and bond portfolios underlying the scenarios. The actual and projected levels for these variables are depicted in Figure 3.1.

o Staff costs reflect the macroeconomic scenarios and a reduction in the staff number by one percent per year;

o The remaining P&L items were projected based on the evolution of average total assets, and also in line with the most recent developments and/or based on judgement about how they would evolve in each scenario.

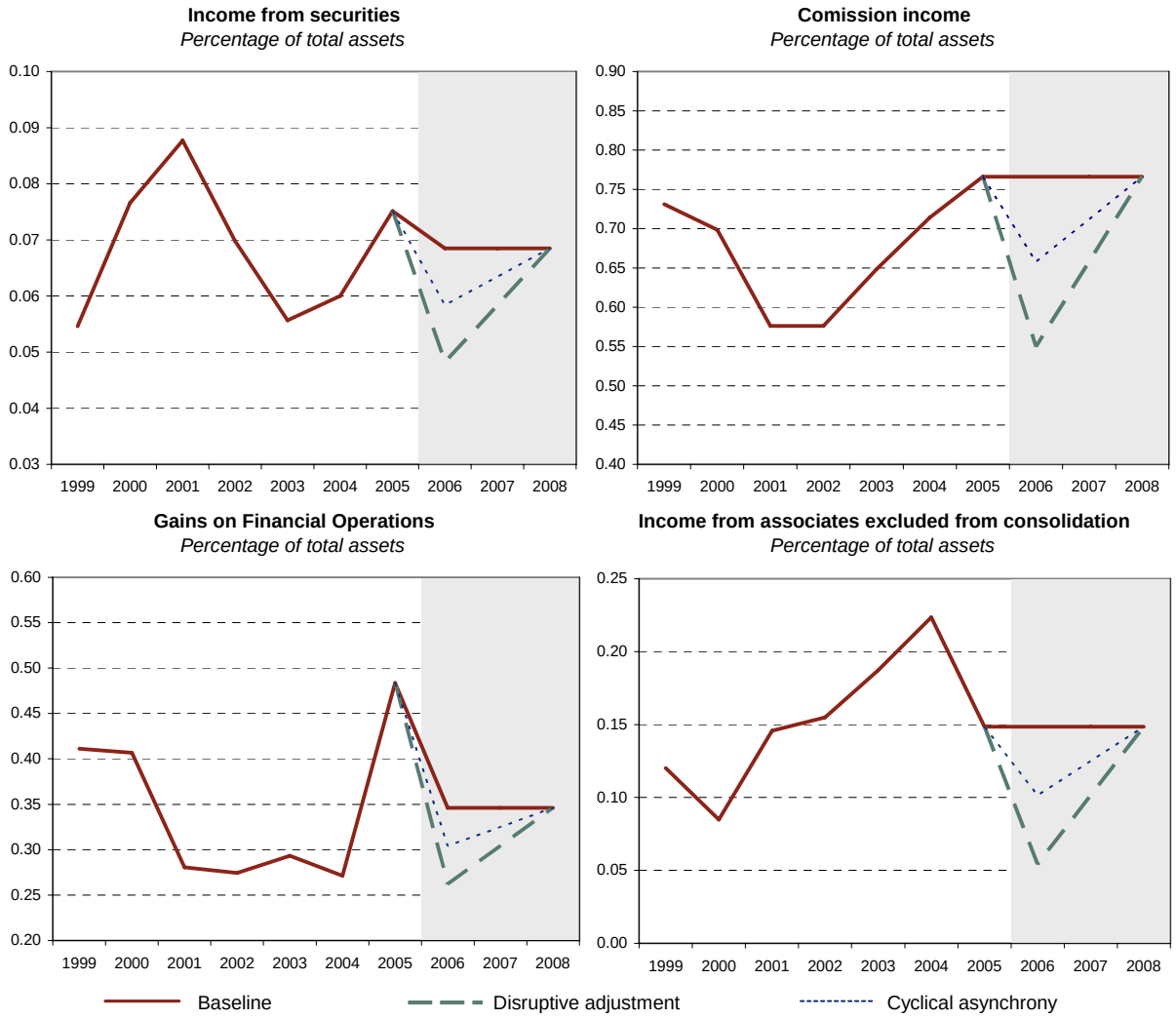
Table 3.2

Assumptions underlying the profit and loss account.

Net interest income	Reflects the joint dynamics of balance-sheet positions and implicit interest rates of major interest bearing assets and liabilities. Non-performing loans do not accrue interest.
Income from securities (dividends and other income from securities representing capital)	Baseline: fixed at the 2005 level (as a percentage of average total assets).
Net commission income	Disruptive adjustment: in 2006, percentile 5 of a normal distribution with mean and standard deviation equal to the 1999-2005 historical series. Afterwards, linear trajectory towards baseline level. Cyclical asynchrony: simple average of the other two scenarios.
Trading and foreign exchange gains	Baseline: fixed at the 1999-2005 sample average (as a percentage of average total assets). Disruptive adjustment: in 2006, equal to the 2002 level, the minimum of the 1999-2005 historical series. Afterwards, linear trajectory towards baseline level. Cyclical asynchrony: simple average of the other two scenarios. In both disruptive adjustment and cyclical adjustment scenarios, value changes reported by banks in their portfolio of shares and bonds in the bottom up exercise were also taken into account.
Other current income (net)	Fixed at the 2005 level in all scenarios (0.15 percent of average total assets).
Gross income	***Summation item***
Staff costs	Average wage growth in line with macro-scenarios. Staff number reduction of 1 percent per year in all scenarios.
Other administrative costs	Fixed at the 2005 level in all scenarios (0.15 percent of average total assets).
Depreciation	
Impairment and provisioning charges	Model-based projection.
Income from associates excluded from consolidation	Baseline: fixed at the 1999-2005 sample average (as a percentage of average total assets). Disruptive adjustment: in 2006, percentile 5 of a normal distribution with mean and standard deviation equal to the 1999-2005 historical series. Afterwards, linear trajectory towards baseline level. Cyclical asynchrony: simple average of the other two scenarios.
Net before tax income	***Summation item***
Taxes on income	13.5 percent of before-tax result.
Net after-tax income (before minority interests)	***Summation item***
Minority interests	15.1 percent of net after-tax income.
Net income	***Summation item***

Figure 3.1

Projections for “Stock-market-related” income items.



Note: figures in the baseline scenario are 1999-2005 averages, except for commissions and income from associates, in which they coincide with the 2005 level. In the disruptive adjustment scenario, the 2006 level corresponds to 2.33 standard deviations away from the 1999-2005 average (1 percent cumulative normal distribution). Afterwards, the variables converge linearly to the level in the baseline scenario. In the cyclical asynchrony scenario, each projection is a simple average of the baseline and disruptive adjustment levels.

In order to project impairment charges in the profit and loss account, a model for the joint simulation of overdue loans and specific provisions was estimated. The model aims at replicating the regulatory system prevailing in Portugal, which requires minimum provisions for delinquent loans depending on the existence of collateral or guarantees, the original maturity of the loan and the time elapsed since delinquency.

3.2 Main results and conclusions

The banking system proved to be resilient to very unfavourable, but still plausible macroeconomic scenarios, incorporating wide ranging sources of risk – both direct and indirect (Tables 3.3 and 3.4).

In what concerns credit quality, the cyclical asynchrony scenario shows, by far, the most severe deterioration, which should reflect, to some extent, the sharp increase in the debt burden of the non-financial private sector, against a background of rising interest rates and negative economic growth (Figure 3.2). In the disruptive adjustment scenario default rates increase only slightly throughout the projection horizon, notwithstanding the negative growth of GDP, as the decrease in interest rates contributes to mitigate credit risk.

In the cyclical asynchrony scenario, income from securities also decreases, even though by a less significant amount. The stability of interest rates and equity prices in the baseline scenario implies a neutral evolution in terms of market risk. In the disruptive adjustment scenario, the strong fall in equity prices together with the decrease in interest rates, affects banks negatively through losses in their financial assets portfolios, as well as in the valuation of their employees' pension funds.

In the baseline scenario, banks' profitability is not foreseen to change significantly throughout the projection horizon. The increase in interest rates in the cyclical asynchrony scenario implies a moderate increase in net interest income. Nevertheless, overall profitability decreases, most notably in 2006, as a result of the decline in income from securities and of losses on financial operations. However, the most severe decline in profitability occurs in the disruptive adjustment scenario, where the decrease in net interest income (resulting from the fall in interest rates) is complemented with a decrease in market-related income (resulting from the disturbances in financial markets). Nevertheless, in both stress scenarios profitability remains comfortably positive.

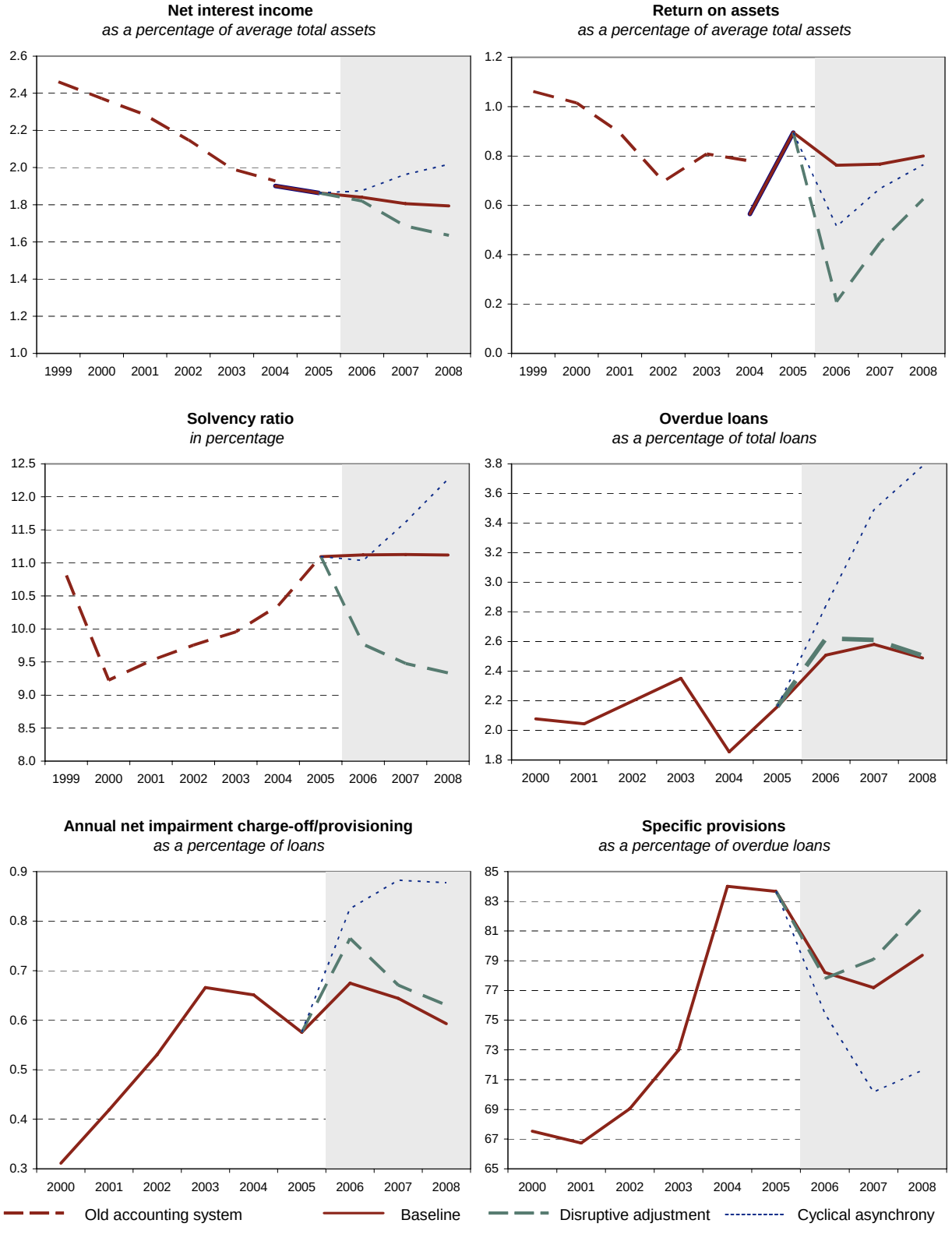
In the baseline scenario, the capital adequacy ratio (CAR) remains broadly unchanged throughout the projection horizon. In turn, the cyclical asynchrony scenario envisages an improvement in the solvency ratio, mostly as a result of the decrease in capital requirements (due to the decrease in credit growth). In contrast, the disruptive adjustment scenario generates a sizeable negative impact on the capital adequacy ratio. In this scenario, the solvency ratio is estimated to decrease 1.2 percentage points in 2006 (mostly due to the fall in equity markets), though remaining clearly above the minimum regulatory level.

In what concerns the impacts on the non-financial private sector, in the baseline scenario, the estimated model forecasts an overall stabilisation of the indebtedness ratios of both households and non-financial corporations (Table 3.5). In both stress scenarios, growth rates of credit to non-financial corporations are significantly lower than in the baseline scenario, most notably in the cyclical asynchrony scenario, resulting in a steady decrease of the indebtedness ratio. Moreover, in this latter scenario, there is a sizeable increase in the corporate debt burden, given the steady increase of interest rates. In what concerns households' indebtedness, the baseline scenario generates a slowdown in total credit to households throughout the projection horizon. In the cyclical asynchrony scenario, households seem to be severely hit by the negative shocks, resulting in a strong decline in indebtedness ratios. The sharp increase in interest rates is likely to induce a strong decline in loan demand. In contrast, the decline in interest rates implicit in the disruptive adjustment scenario results in projected growth rates of credit to households higher than those seen in the baseline scenario, even though also slowing down.

The results of the top-down stress test exercise highlight two main sources of risk in banks' portfolios: market and credit risk. All things considered, it can be concluded that banks' financial position is more sensitive to stock market risks than to credit risks, given that the strong decrease in credit quality in the cyclical asynchrony scenario (motivated by the interest rates increase in a context of negative economic growth) has a smaller impact on profitability and solvency than the financial market disturbances implied in the disruptive adjustment scenario. All in all, the current profitability and solvency levels are sufficient to withstand the impacts associated to severe but plausible macroeconomic and financial conditions.

Figure 3.2

Financial variables in the baseline and alternative stress scenarios.



Note: there is a statistical break in the series in 2004 as banks adopted the International Accounting Standards in 2005. Year-on-year growth rates.

Table 3.3

Balance sheet.

Baseline

	year on year growth rate					
	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Interbank assets	28.8	-22.2	13.8	0.0	0.0	0.0
Credit to customers	1.8	3.6	9.8	3.8	4.1	4.5
Securities	26.2	23.0	21.7	2.4	3.4	3.7
Non-financial assets	-1.3	-5.2	7.9	0.0	0.0	0.0
Other assets	10.6	2.5	22.8	2.4	3.4	3.7
Total assets	7.4	1.4	12.1	3.1	3.5	3.8
Market financing (interbank+securities issued+subordinated debt)	13.4	-1.5	16.8	4.7	6.2	5.5
Funding from customers	2.8	2.8	4.5	1.5	0.9	2.0
Other liabilities	15.0	-0.3	52.2	2.4	3.4	3.7
Capital and reserves	11.2	8.2	26.1	5.1	5.8	6.2
Net income (before minority interests)	22.2	-0.3	44.9	7.3	3.9	8.1

Disruptive adjustment

	year on year growth rate					
	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Interbank assets	28.8	-22.2	13.8	0.0	0.0	0.0
Credit to customers	1.8	3.6	9.8	5.1	5.3	4.6
Securities	26.2	23.0	21.7	-2.8	1.2	1.3
Non-financial assets	-1.3	-5.2	7.9	0.0	0.0	0.0
Other assets	10.6	2.5	22.8	1.7	1.2	1.3
Total assets	7.4	1.4	12.1	3.3	4.0	3.5
Market financing (interbank+securities issued+subordinated debt)	13.4	-1.5	16.8	8.4	9.3	7.2
Funding from customers	2.8	2.8	4.5	0.2	-0.7	-0.1
Other liabilities	15.0	-0.3	52.2	1.7	1.2	1.3
Capital and reserves	11.2	8.2	26.1	-4.2	5.6	6.5
Net income (before minority interests)	22.2	-0.3	44.9	-65.9	121.8	44.6

Cyclical asynchrony

	year on year growth rate					
	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Interbank assets	28.8	-22.2	13.8	0.0	0.0	0.0
Credit to customers	1.8	3.6	9.8	1.0	-1.4	-1.8
Securities	26.2	23.0	21.7	0.6	1.4	1.6
Non-financial assets	-1.3	-5.2	7.9	0.0	0.0	0.0
Other assets	10.6	2.5	22.8	1.0	1.6	1.7
Total assets	7.4	1.4	12.1	0.8	-0.8	-1.0
Market financing (interbank+securities issued+subordinated debt)	13.4	-1.5	16.8	1.6	-1.2	-2.6
Funding from customers	2.8	2.8	4.5	0.2	-1.4	-0.8
Other liabilities	15.0	-0.3	52.2	1.0	1.6	1.7
Capital and reserves	11.2	8.2	26.1	0.5	5.6	5.6
Net income (before minority interests)	22.2	-0.3	44.9	-28.4	29.9	13.5

Note: there is a statistical break in the series in 2004 as banks adopted the International Accounting Standards in 2005.

Table 3.4

Profit and loss account.

Baseline

	Year-on-year growth rate								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Net interest income	34.2	13.4	-1.3	-2.4	-0.1	5.2	5.9	1.4	2.9
Income from securities	93.8	34.6	-16.1	-15.7	11.1	34.4	-2.1	3.3	3.6
Net comission income	33.6	-0.8	5.0	16.9	12.7	15.1	7.3	3.3	3.6
Gains and losses on financial operations	37.1	-33.6	1.0	17.9	-9.7	91.3	-23.2	3.3	3.6
Other current income (net)	17.0	56.6	8.8	18.5	16.3	-28.7	10.0	3.3	3.6
Gross income	**34.2**	**9.4**	**0.4**	**3.8**	**3.9**	**12.9**	**2.0**	**2.2**	**3.2**
Extraordinary income	-17.2	-95.5	452.0	30.2	n.a.				
Staff costs	29.5	3.5	2.8	4.3	2.4	-10.0	1.9	1.8	1.8
Other administrative costs	25.7	13.2	2.9	4.4	4.5	4.6	7.3	3.3	3.6
Depreciations	13.6	7.5	5.7	4.6	3.0	-17.2	7.2	3.3	3.6
Impairment and provisioning charges	44.5	-22.6	38.2	-0.2	1.5	-1.5	24.1	-1.6	-3.2
Income from associates excluded from consolidation (net)	298.5	-38.0	-20.1	240.1	-1.9	-41.8	26.8	3.3	3.6
Net before tax income	**31.6**	**2.2**	**-17.7**	**19.3**	**-3.4**	**70.8**	**-8.6**	**3.9**	**8.1**
Taxes on income	24.5	-6.0	-14.5	3.7	-22.3	76.3	-8.6	3.9	8.1
Net after tax income (before minority interests)	**33.1**	**3.8**	**-18.3**	**22.2**	**-0.3**	**70.0**	**-8.6**	**3.9**	**8.1**
Minority interests	20.0	-14.0	-17.5	14.7	8.0	62.2	-6.9	3.9	8.1
Net income	**37.6**	**9.1**	**-18.5**	**24.0**	**-2.2**	**71.4**	**-8.9**	**3.9**	**8.1**

Disruptive adjustment

	Year-on-year growth rate								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Net interest income	34.2	13.4	-1.3	-2.4	-0.1	5.2	4.9	-4.1	0.7
Income from securities	93.8	34.6	-16.1	-15.7	11.1	34.4	-31.0	25.4	21.8
Net comission income	33.6	-0.8	5.0	16.9	12.7	15.1	-22.9	24.1	20.8
Gains and losses on financial operations	37.1	-33.6	1.0	17.9	-9.7	91.3	-64.9	104.1	14.7
Other current income (net)	17.0	56.6	8.8	18.5	16.3	-28.7	10.1	3.6	3.8
Gross income	**34.2**	**9.4**	**0.4**	**3.8**	**3.9**	**12.9**	**-12.2**	**8.8**	**7.4**
Extraordinary income	-17.2	-95.5	452.0	30.2	n.a.				
Staff costs	29.5	3.5	2.8	4.3	2.4	-10.0	1.5	1.1	1.2
Other administrative costs	25.7	13.2	2.9	4.4	4.5	4.6	7.5	3.6	3.8
Depreciations	13.6	7.5	5.7	4.6	3.0	-17.2	26.7	3.6	3.8
Impairment and provisioning charges	44.5	-22.6	38.2	-0.2	1.5	-1.5	43.1	-8.1	-2.0
Income from associates excluded from consolidation (net)	298.5	-38.0	-20.1	240.1	-1.9	-41.8	-53.7	93.7	52.0
Net before tax income	**31.6**	**2.2**	**-17.7**	**19.3**	**-3.4**	**70.8**	**-74.8**	**121.8**	**44.6**
Taxes on income	24.5	-6.0	-14.5	3.7	-22.3	76.3	-74.8	121.8	44.6
Net after tax income (before minority interests)	**33.1**	**3.8**	**-18.3**	**22.2**	**-0.3**	**70.0**	**-74.8**	**121.8**	**44.6**
Minority interests	20.0	-14.0	-17.5	14.7	8.0	62.2	-74.4	121.8	44.6
Net income	**37.6**	**9.1**	**-18.5**	**24.0**	**-2.2**	**71.4**	**-74.9**	**121.8**	**44.6**

Cyclical asynchrony

	Year-on-year growth rate								
	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Net interest income	34.2	13.4	-1.3	-2.4	-0.1	5.2	6.8	4.7	1.9
Income from securities	93.8	34.6	-16.1	-15.7	11.1	34.4	-17.5	8.7	7.0
Net comission income	33.6	-0.8	5.0	16.9	12.7	15.1	-8.9	8.3	6.7
Gains and losses on financial operations	37.1	-33.6	1.0	17.9	-9.7	91.3	-30.9	12.4	-2.6
Other current income (net)	17.0	56.6	8.8	18.5	16.3	-28.7	8.8	0.0	-0.9
Gross income	**34.2**	**9.4**	**0.4**	**3.8**	**3.9**	**12.9**	**-2.7**	**6.1**	**2.4**
Extraordinary income	-17.2	-95.5	452.0	30.2	n.a.				
Staff costs	29.5	3.5	2.8	4.3	2.4	-10.0	1.9	1.8	1.9
Other administrative costs	25.7	13.2	2.9	4.4	4.5	4.6	6.1	0.0	-0.9
Depreciations	13.6	7.5	5.7	4.6	3.0	-17.2	25.1	0.0	-0.9
Impairment and provisioning charges	44.5	-22.6	38.2	-0.2	1.5	-1.5	43.2	2.0	-2.6
Income from associates excluded from consolidation (net)	298.5	-38.0	-20.1	240.1	-1.9	-41.8	-14.4	23.3	17.8
Net before tax income	**31.6**	**2.2**	**-17.7**	**19.3**	**-3.4**	**70.8**	**-39.0**	**29.9**	**13.5**
Taxes on income	24.5	-6.0	-14.5	3.7	-22.3	76.3	-39.0	29.9	13.5
Net after tax income (before minority interests)	**33.1**	**3.8**	**-18.3**	**22.2**	**-0.3**	**70.0**	**-39.0**	**29.9**	**13.5**
Minority interests	20.0	-14.0	-17.5	14.7	8.0	62.2	-37.9	29.9	13.5
Net income	**37.6**	**9.1**	**-18.5**	**24.0**	**-2.2**	**71.4**	**-39.2**	**29.9**	**13.5**

Note: there is a statistical break in the series in 2004 as banks adopted the International Accounting Standards in 2005.

Table 3.5

Indicators for the private non-financial sector.

	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Households' indebtedness (%Disposable income)									
Baseline	87	92	99	106	112	119	122	123	123
Disruptive adjustment	87	92	99	106	112	119	125	132	138
Cyclical asynchrony	87	92	99	106	112	119	119	115	109
Households' debt burden - interest only (%Disposable income)									
Baseline	5.3	6.3	5.6	5.1	5.0	5.1	5.4	5.6	5.7
Disruptive adjustment	5.3	6.3	5.6	5.1	5.0	5.1	4.1	4.0	4.3
Cyclical asynchrony	5.3	6.3	5.6	5.1	5.0	5.1	6.9	7.6	8.0
Non-financial corporations indebtedness (%GDP)									
Baseline	81.0	91.5	93.4	95.9	94.1	96.9	96.7	96.4	96.3
Disruptive adjustment	81.0	91.5	93.4	95.9	94.1	96.9	96.4	96.2	96.3
Cyclical asynchrony	81.0	91.5	93.4	95.9	94.1	96.9	96.7	94.5	91.9
Non-financial corporations' debt burden - interest only (%GDP)									
Baseline	4.2	5.0	4.5	4.0	3.8	3.8	3.9	3.9	3.9
Disruptive adjustment	4.2	5.0	4.5	4.0	3.8	3.8	3.6	2.7	2.6
Cyclical asynchrony	4.2	5.0	4.5	4.0	3.8	3.8	4.2	5.2	5.7
Household debt y-o-y growth rate(a)									
Baseline	19.8	12.2	11.8	9.9	10.4	9.0	5.6	4.5	4.2
Disruptive adjustment	19.8	12.2	11.8	9.9	10.4	9.0	8.9	8.0	6.0
Cyclical asynchrony	19.8	12.2	11.8	9.9	10.4	9.0	2.0	-1.5	-2.6
Non-financial corporations debt y-o-y growth rate (a)									
Baseline	18.8	19.7	7.0	4.4	1.6	4.0	0.7	2.7	3.5
Disruptive adjustment	18.8	19.7	7.0	4.4	1.6	4.0	-0.4	0.5	1.4
Cyclical asynchrony	18.8	19.7	7.0	4.4	1.6	4.0	-0.7	-1.3	-1.3

Note: (a) total interest-bearing debt.

4 Bottom-Up Stress Test

In the bottom-up exercise banks were asked to translate the macroeconomic scenarios into their individual financial statements. In order to ensure as much consistency as possible, it was crucial to identify from the outset the type of risk analysis that banks are currently implementing, as well as the type of information that was needed as an input to that analysis. This identification required a close collaboration between the Economics and Research Department and the Banking Supervision Department of Banco de Portugal.

Banco de Portugal supplied each individual bank with the same macroeconomic scenarios that were used in the top-down exercise, together with a description of the rationale for each scenario. The “stressed” path for a set of related endogenous variables made available for the top-down stress test exercise, such as the growth in credit to households and non-financial corporations, was also provided to banks. Finally, banks were also provided with estimated probabilities of default, although they could choose to use their own estimates. The probabilities of default were estimated distinguishing two main classes of credit: non financial corporations and households. The estimated probabilities of default for non financial corporations were crossed by size of exposure and economic sector of the firm. The estimated probabilities of default of households were divided into two categories: housing purposes and other purposes. Finally, probabilities of default for a residual class of credit denominated “other credits” were also provided. Banks were then asked to compute the impact of each scenario on their individual accounts.

This exercise was subsequently compared with the top-down approach. The exercise also allowed assessing the dispersion of results among reporting banks in each of the stress scenarios. Although this exercise was only conducted with the major six banking groups, its results can be considered representative, given that these banking groups accounted for more than 80 per cent of the total assets of the Portuguese banking system in December 2004.

This section starts by briefly describing the methodology and the results used to compute the probabilities of default in section 4.1. It then presents how the whole exercise was implemented in section 4.2. Section 4.3 overviews the portfolio of the banking groups under analysis. Finally, the main results of the bottom-up stress test are discussed in sections 4.4 and 4.5.

4.1 Estimation of Probabilities of Default

Credit risk is of particular relevance in the analysis of financial stability. In order to consider credit risk in the stress test, it is necessary to estimate default rates of the two main credit categories: credit to non-financial corporations and credit to households. These estimated default rates were used as inputs to the bottom-up stress exercises.

4.1.1 Credit default of non-financial corporations: a summary

In what concerns credit defaults of non-financial corporations, the general idea was to incorporate macroeconomic variables within a model with an adequate description of each loan and of the associated obligor. This approach was motivated by the fact that, while it is widely accepted that banks have large expertise in analysing corporate credit risk given firm financial data, it is not clear if their methodologies consider the impact of macroeconomic factors in the determination of the probability of a default. In addition, credit portfolio of banks may not be diversified enough in order to estimate default probabilities for firms by economic activity. Therefore, using data mainly from the *Central de Responsabilidades de Crédito*, the Portuguese credit register, default probabilities were estimated for non-financial corporations in different economic activities and different average size of total credit exposure. This exercise was carried over for the three macroeconomic scenarios outlined in Section 2.

The *Central de Responsabilidades de Crédito* database consists of monthly credit information on each Portuguese firm in the period 1995-2004. Banks and other financial institutions are required to report credit information on an individual basis to Banco de Portugal. They have online access to this information and may use it to assess the risk profile of each firm. The information available characterizes loans and their repayment status. The other data source utilized was the *Estatísticas Gerais* database, which includes legal and other information on each active or extinct firm in Portugal. This database was used to obtain the economic sector of each firm.

The econometric procedure consists of the estimation of a model with a probit specification where the event of interest is credit "default". A default occurs when positive past due amounts occur in three consecutive months, and the amount past due three months ago was zero. The loan is then removed from the sample until either it disappears from the *Central de Responsabilidades de Crédito* or the impaired amount returns to zero.

Two types of variables were used to proceed with the estimation of the probit model: macroeconomic regressors, and loan- and firm-level regressors. At the macroeconomic level, the following variables were used: unemployment, short-term interest rates and deviations of GDP from trend. At the loan-level, two dummy variables were constructed. One dummy variable indicates whether the firm has defaulted on credits other than the loan under observation. The other dummy indicates the event that the borrower has on average defaulted on more than half of its loans during the current quarter, not including the loan under consideration. At the firm-level, categorical variables for the economic sector and the firm's total exposure were considered. Other dummy variables were introduced to account for the introduction of the euro in 1999, seasonal effects and interactions between regressors. The model estimated rates of default fit the sample default rates fairly well, both in the whole sample and conditioning on economic sector or credit dimension classes. Finally, the model was used to predict default rates under different macroeconomic scenarios.

Results

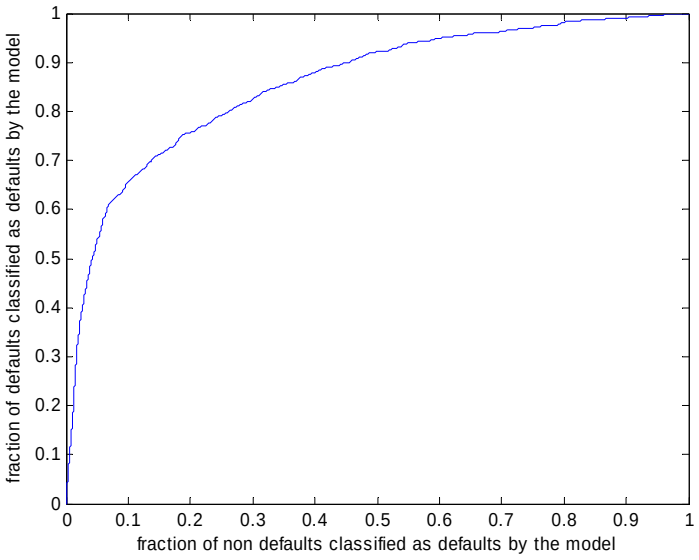
The estimated model shows a large negative impact of deviations of GDP from trend on the default rates in the period 1995-2004. As for unemployment, evidence is mixed, with default rates possibly varying across sectors and over time. The general behaviour of the model will be clear once it is applied to estimate default rates for the 2005-2008 period under different macroeconomic scenarios.

For each observation, the probability of default is predicted using a conditional probability equation. The default rates estimated by the model as the mean of the predicted probability of default fit the sample default rates fairly well, both in the whole sample and conditioning on economic sector or credit dimension classes.

The Receiver Operating Characteristic curve, or simply ROC curve, and the so-called "power" of the model confirm this. The ROC curve is obtained by plotting the fraction of actual defaults correctly guessed by the model against the fraction of non defaults incorrectly classified by the model, for different cut-offs of the binary response model.[6] Figure 4.1 presents the model's ROC curve. A perfect model would be such that, for some cut-off, all actual defaults and non defaults were correctly guessed.

Figure 4.1

Receiver Operating Characteristic curve



For an extremely low cut-off (say, minus infinity) all loans are classified as defaults by the model. The fraction of non defaults classified as defaults is one, and the fraction of defaults classified by the model as defaults is also one. This corresponds to the upper right corner of

6 The cut-off is the level of the probit latent variable above which an observation is classified as a default. See Antunes, Ribeiro e Antão (2006) for a more detailed description and assessment of the credit default model, including a thorough explanation of the ROC curve.

Figure 4.1. Likewise, for an extremely high cut-off (say, infinity) all loans are classified as non-defaults and are thus in the lower left corner of the Figure. In the ROC curve it is possible to observe that, for instance, the model incorrectly guesses about 25 percent of non defaults if the purpose is to be sure that about 80 percent of defaults are correctly guessed by the model.

A random classification would yield a linear ROC curve between points (0,0) and (1,1), meaning that, for instance, if the goal of the researcher was to classify correctly 25 per cent of the actual defaults, an incorrect classification of actual non-defaults in 25 per cent of the cases would have to be accepted. The ROC curve of a perfect model for any cut-off would be a straight line between points (0,1) and (1,1). This suggests that the area below the ROC curve is a good measure of the overall fit of the model. This is called the "power" of the model. A power of ½ would correspond to a random model; a power of 1 would correspond to a perfect model.[7] The value for our model is 0.86, which compares favourably with comparable models in the literature. More importantly, calculating ROC curves for subsets of the loans yields good overall model fits. For example, the power for loans in the fourth quarter of 1995 is 0.84, while the power in the fourth quarter of 2004 is 0.86.

Predicting default rates

In order to use the model to predict default rates under different macroeconomic scenarios, assumptions about the credit portfolio have to be made, such that the essential characteristics of the financial sector credit portfolio remain unchanged throughout the projection horizon. There are essentially two reasons for this assertion. The first is that the default process, especially for large firms, is a slow one, and the occurrence of defaults is not likely to significantly affect the portfolio composition in a relatively short period. The second is that no obvious assumption about the characteristics of new loans is available.

By looking at the 2004 average portfolio and feeding in values for the macroeconomic variables from the different scenarios, the corresponding default rates can be estimated. Recall that there are three distinct macroeconomic scenarios: a "baseline" scenario and two stress scenarios, "disruptive adjustment" and "cyclical asynchrony" (see Section 2.1 in Chapter 2). The three scenarios are characterized in terms of the evolution of the short-term interest rates, the real GDP growth rate around its trend and the unemployment rate. See Table 2.2 for the values of the macroeconomic variables used in this model.

The estimated average default rates were calculated using the default rates estimated by economic sector and size class and the entire corporate credit portfolio as of end-2004. In the disruptive adjustment scenario, average default rates rise by 0.7 percentage points from 2005 to 2006, while the increase in the cyclical asynchrony case is 0.5 percentage points. From 2007 to 2008, the increases for the two scenarios are, respectively, 0.7 and 1.2 percentage points.

7 See Dwyer (2005) for a definition of power in the context of credit default models.

As expected, the two stress scenarios yield much larger probabilities of default than the baseline. The baseline scenario is relatively benign in terms of the default rates, which in 2008 are slightly lower than in 2005. In the other two scenarios rates of default deteriorate across-the-board, with the largest rises occurring in 2006 for the disruptive adjustment (due essentially to low GDP growth), and in 2008 for the cyclical asynchrony (due to the rise in the interest rate).

Figure 4.2 presents estimated probabilities of default by economic sector as a fraction of the Energy sector probability of default in 2005. It also presents the weight of the credit to each economic sector as of end-2004. These weights were assumed constant for all years. Among the sectors that display higher default probabilities are Construction, Real Estate and services provided mainly to firms and Manufacturing (together, these three sectors account for nearly half of the corporate credit portfolio). The sectors with the lowest probabilities of default are Energy and Transportation.

Figure 4.3 presents an index of the estimated probabilities of default in the three scenarios for firms in all economic sectors, by size of total exposure and year. Class labelled “small exposures” includes the exposures of non-financial corporations vis-à-vis the entire banking system between 1 thousand and 50 thousand euros; “intermediate exposures” includes exposures between 50 thousand and 1 million euros; and “large exposures” are those above 1 million euros. The base value is the predicted probability of default for loans by firms with large exposures in 2005. The area of each class is proportional to the weight of that class in the total exposure to non-financial corporations. In general, loans from larger firms (which have on average larger total exposures) are less likely to become impaired. Given the high concentration of the overall corporate loan portfolio in this type of credit, this translates into a relatively favourable average probability of default.

Figure 4.2a

Sectoral composition of credit to non financial corporations as of end-2004.

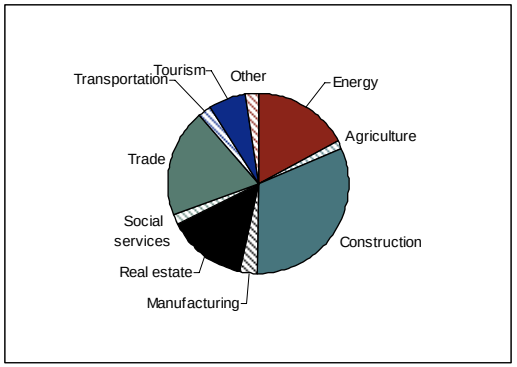


Figure 4.2b

Index of predicted annual default rates by economic sector. Base: predicted default rate for the Energy sector in 2005.

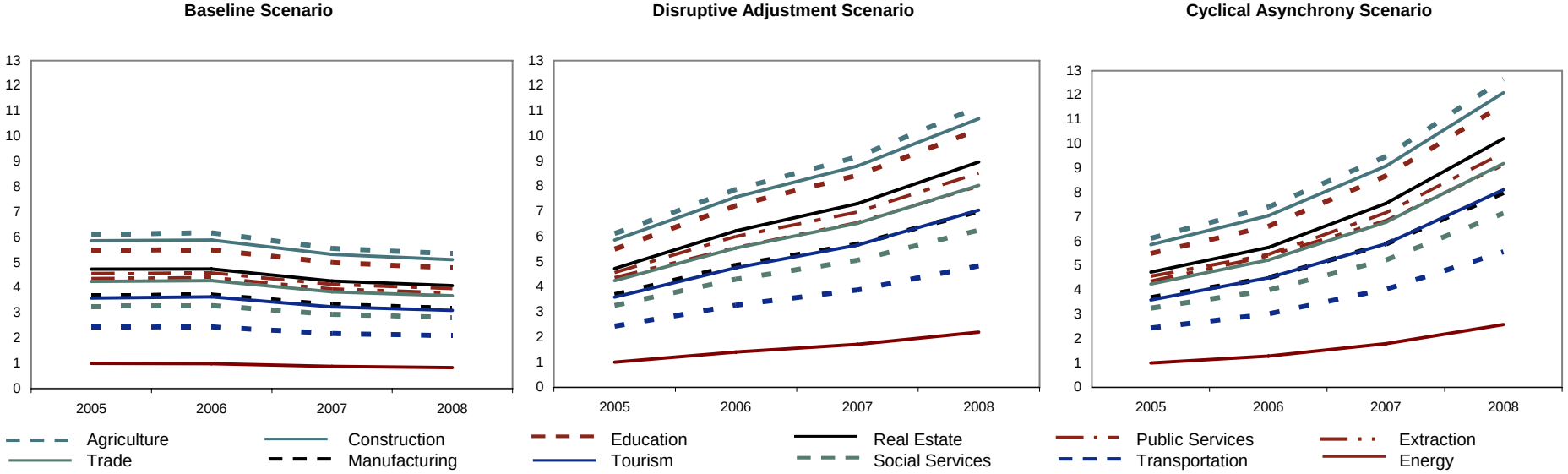
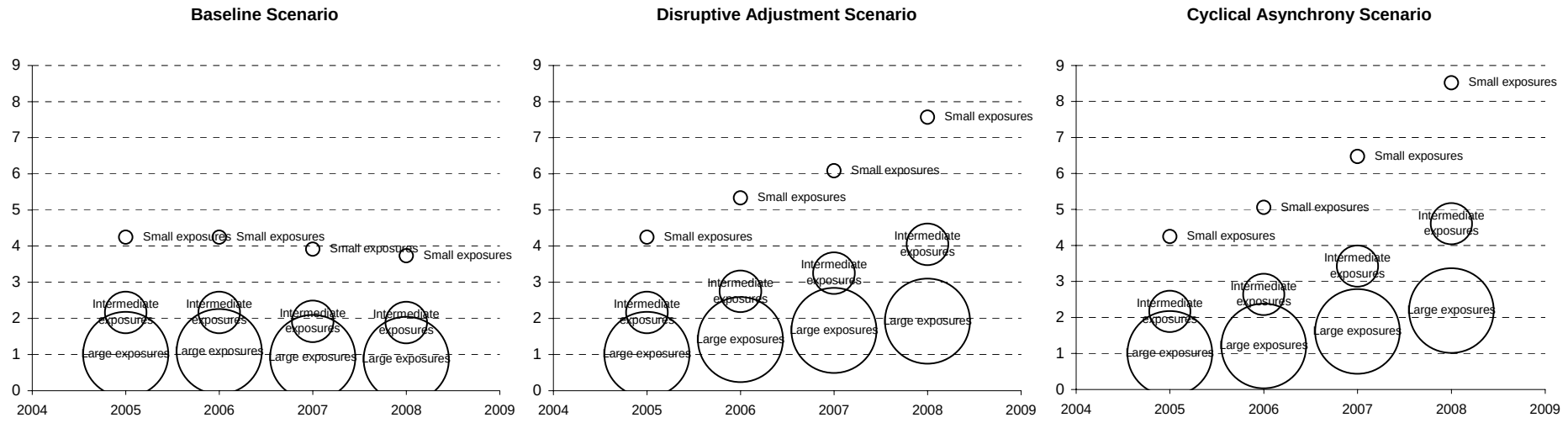


Figure 4.3

Index of predicted annual default rates by class of exposure. Base: predicted default rate for the large exposures class in 2005.



Note: the size of the circle is proportional to the weight of each exposure class on total exposure to non-financial firms as of December 2004

4.1.2 Credit default of households: a summary

The estimation of household default rates has some operational difficulties related to the size of the datasets, to their changing coverage of the universe and to difficulties in establishing a unique time series relationship with the same debtor. Besides, the information of the *Central de Responsabilidades de Crédito* does not allow the breakdown between housing and loans for other purposes. Given these limitations, the approach consisted of estimating cyclical factors impacting on default probabilities assuming that these are priced into bank loan interest rates. Some assumptions were used, namely in terms of the semi-price elasticity of the demand for loans, and in terms of competition between banks, which was assumed to remain broadly unchanged.

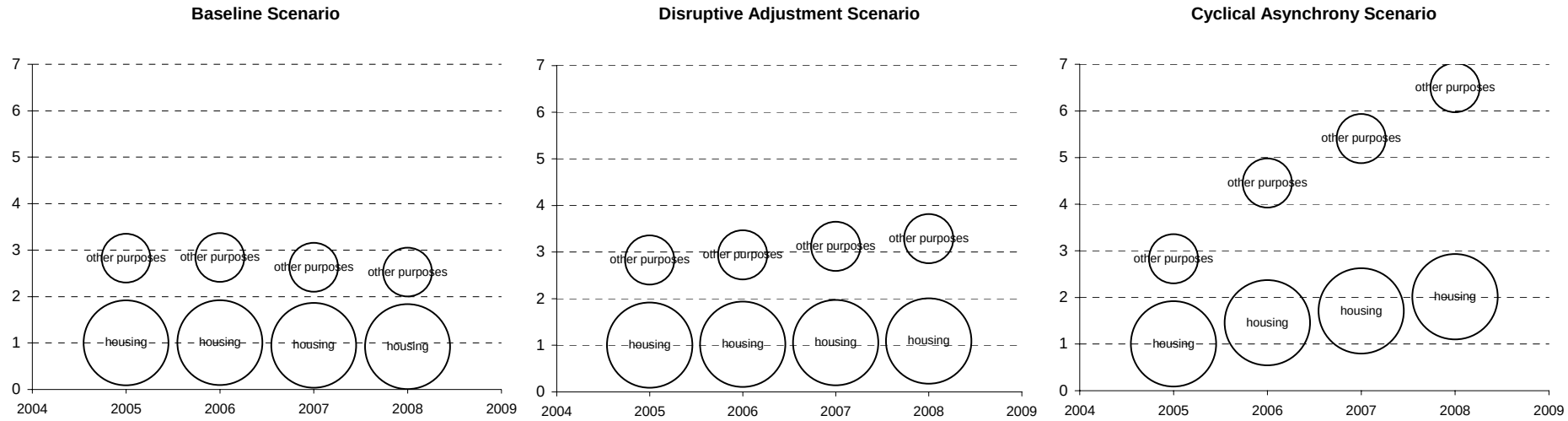
The estimation procedure consisted of regressing the spread in three loan segments (the corporate sector, the housing mortgage sector and other loans granted to households) on macroeconomic variables such as unemployment and short term interest rates. Spreads were constructed confronting loan rates on outstanding amounts with the money market rate for the most frequent re-pricing period for each credit category (three months for the corporate sector and six months for the household sector). A general Autoregressive Distributed Lag (ADL) structure was assumed for the dynamic relationship between variables. The estimated spread fit the actual spread fairly well for the three types of credit considered.

The model was then used to predict probabilities of default under the baseline and the stress scenarios. This task involved three main steps. The first one consisted of anchoring the level for the default probability in 2005. The second step was to compare the results of this model for the corporate sector with the results of the model mentioned in the previous section for the corporate sector. The last step was to calibrate the evolution of probability of default for the two household segments in order to preserve their dynamics while taking into account the relationship between the estimates obtained in both models for the corporate sector.

Figure 4.4 presents an index of predicted probabilities of default of the two categories of credit to households: housing purposes and other purposes. In general, probabilities of default of the household sector increase in both stress scenarios, with the most severe increases occurring in the cyclical asynchrony scenario due, mainly, to the increase in interest rates. The probability of default of credit for housing purposes is smaller, which helps reduce the average probability of default of households, as this type of credit accounts for around three quarters of total credit to households. Additionally, there is no evidence in favour of house prices overvaluation; hence, substantial changes in house prices are not expected.

Figure 4.4

Index of predicted default rates of credit to households, annual values. Base: predicted default rate for loans for housing purposes in 2005.



Note: the size of the circle represents the weight of each household category of credit in December 2005.

Finally, Table 4.1 summarizes the projected evolution of the probabilities of default for the four categories of credit compared to the evolution in the baseline scenario. In general, and as mentioned before, the increase in the estimated probabilities of default is larger in the cyclical asynchrony scenario.

Table 4.1

Estimated probabilities of default. Percent increase relative to baseline.

	Disruptive adjustment			Cyclical asynchrony		
	2006	2007	2008	2006	2007	2008
Corporations	29	65	111	20	71	139
Households - housing purposes	1	11	19	45	80	119
Households - other purposes	4	19	30	57	106	158
Other credits	13	35	58	37	82	136

4.2 Implementation of the bottom-up exercise

It was the first time that a bottom-up stress test was undertaken in conjunction with a top down exercise. This had the advantage of providing a cross-check of the results of the top-down approach and also allowed to capture heterogeneity among institutions.

In mid-February 2006, a questionnaire was sent to the major six banking groups: Montepio Geral (CEMG); Grupo Espírito Santo (ESFG); Banco Comercial Português (BCP), Banco Santander Totta (BST), Banco Português de Investimento (BPI) and Caixa Geral de Depósitos (CGD). The six institutions considered in the stress exercise are a sub-group of the thirteen institutions which, in 2005, adopted the International Accounting Standards (IAS), and represent around 80 percent of the Portuguese banking system (in terms of total assets as of December 2004). Various meetings were held with banks to exchange views on the questionnaires and to provide follow-up guidance. Banks send their reports back by mid-April. The results were then discussed within the IMF mission by mid-May.

Two institutions were asked to do the exercise as conglomerates, that is, including both the banking and the insurance segments. However, one institution submitted a proposal to change the structure of the group and ended up doing the exercise considering only the banking activity. In addition, for one of the participating banks, the results do not include the indirect impact stemming from shocks in the balance-sheet of its employees' pension fund[8]. Finally, one of the banking groups underwent a capital increase during the implementation of the exercise. The results presented herein already reflect this capital increase.

8 This institution is the smallest among the reporting banking groups. Further, it has a relatively small-sized employees' pension fund and the share of equity is only 7 percent of the fund's total assets.

The questionnaire was divided into two sections. In the first section, banks first task was to report their situation in terms of balance sheet, operating profits and capital as of 31 December 2005 by exposure type[9]. They should also report the asset composition and total liabilities of the bank employees' pension funds on 31 December 2005. Then, banks were asked to perform a set of scenario-based stress-testing exercises, including indirect impacts stemming from banks employees' pension funds. In this section, banks should report the separate impact of individual shocks on each risk factor, and also report a full set of accounts considering all shocks together. To perform their stress test, banks received information on the evolution of macroeconomic variables, credit growth and probabilities of default for the baseline and the two stress scenarios[10]. As mentioned, Banco de Portugal also sent detailed information on the corporate sector probabilities of default crossing economic sector and size of credit.

Banks were then asked to project their financial position (in terms of total assets, operating profits and regulatory capital) over a 3-year horizon under the assumptions set out in the baseline scenario and in the two stress scenarios. Additionally banks were also asked to project the banks employees' pension funds asset and liability values, and the effect of changes in the value of these funds on the bank's operating profits and regulatory capital.

To complement the scenario exercise, banks were asked to write a report with a qualitative assessment of the possible consequences of the different scenarios in terms of liquidity risk, for instance taking into consideration a possible Portuguese sovereign rating downgrade.

In the second section of the questionnaire, banks were asked to perform some sensitivity tests. This part aimed at assessing the impact on assets, operating profits and regulatory capital of large and instantaneous shocks on risk factors, holding all the other factors constant. In order to do this, banks received information on the size of the shocks to be considered in the sensitivity tests. Table 4.2 summarizes the size of shocks used in the exercise. See Box 1 for a more detailed description of the calculation of the sensitivity shocks.

9 In the case of the conglomerate, they should also present analogous information on the affiliated insurance companies and on the combined position of the banking and insurance segments of the financial group.

10 Even though banks were provided with default probabilities and recovery rates estimated by Banco de Portugal, they were free to use their own internal estimates of these variables. However, only one of the participating banking groups chose to use its internal estimates to anchor the starting point in 2005. For 2006-2008, this bank used the growth rates implicit in the default probabilities provided by Banco de Portugal. Notwithstanding this slight difference in procedure, the final figure for this risk factor ended up to be similar to the one proposed by Banco de Portugal and assumed by all other institutions.

Table 4.2

Overview of Sensitivity Shocks.

Risk factor	Nature of shock	Size of shock
Interest rate risk	Joint change of 3-month and 10-year interest rates (a),(b)	100 bps and 50 bps up
		100 bps and 50 bps down
		200 bps and 100 bps up
		200 bps and 100 bps down
	Pivotal change of 10-year interest rate (b), (c)	50 bps up
		50 bps down
Foreign currency risk	Change of euro exchange rates (d)	15 percent up
		15 percent down
Equity price risk	Change of equity prices (e)	30 percent up
		30 percent down
Volatility risk	Change of implied volatility of financial market prices (f)	30 percent up
		30 percent down

Notes: (a) Shocks to interest rates with other maturities obtained by linear interpolation. Stress tests for pension schemes incorporate changes in the actuarial discount rate of 25 bps up, 25 bps down, 50 bps up and 50 bps down, respectively.

(b) Interest rate changes are equal in all currencies.

(c) A pivotal change implies a change in the 10-year interest rate, keeping the 3-month interest rate fixed.

(d) Change in euro exchange rate is applicable to all currencies. An upward shock of 15 percent thus represents a 15 percent depreciation of the euro with respect to all other currencies.

(e) Equity price shock is applied simultaneously to all equity markets.

(f) Volatility shock is applied simultaneously to all financial market prices (interest rates, exchange rates and interest rates). If the volatility level is 10 percent initially, a 30-percent increase implies that the volatility level rises from 10 to 13.

Box 1 – Size of shocks for the sensitivity analysis

The size of the shocks used in the Portuguese FSAP sensitivity tests were rooted on historical data on equity prices, short and long term yields of government debt from countries that currently are members of the European Monetary Union, the EUR/USD exchange rate (in euros per dollar), and implied volatility of equity prices, exchange rates and interest rates. The shocks are similar to the ones proposed by other comparable economies that have undergone the same type of sensitivity tests, which analyse the ability of banks to absorb large shocks in a relatively short period of time. A brief assessment of the likelihood of large shocks in the Portuguese financial markets is now provided.

To assess the likelihood of sudden shocks affecting the Portuguese economy, one has to keep in mind some aspects of the Portuguese economy in recent years. Portugal's participation in the euro area arguably resulted in a very different economic environment. Therefore, sensitivity tests could not be designed using exclusively historical data for the Portuguese economy. The sensitivity tests were based on the behaviour of economic variables of countries (or sets of countries) that most resemble the current euro area economy.

Historical data

The source for yields estimates is the European Central Bank. For the period ending at the time of the euro introduction, they were computed by the ECB using end-of-month government debt yields from the countries that belong to the European Monetary Union

as of end-2005. These “euro yield” measures are thus a synthetic backward extension of current euro yields.

The DEM/USD exchange rate was used for the EUR/USD exchange rate prior to the introduction of the euro in 1999.

For the equity prices, the EuroStoxx, Standard & Poors 500 and PSI20 indices were used.

Table 1 presents summary statistics using end-of-month data for the 3-month and the 10-year yields, and using a sliding window of 22 business days for the equity indices (EuroStoxx, S&P 500 and PSI20) and the EUR/USD exchange rate.[11]

For the purpose of the FSAP exercise, we used the largest historical variations as a rough guideline for the proposed shocks.

Table 1

Summary statistics of monthly data.

Stats	EuroStoxx (%)	S&P (%)	PSI20 (%)	Euro 3 months (pp)	Euro 10 years (pp)	EUR/USD (%)
N	4893	6553	3266	311	309	4723
Mean	0.69	0.93	0.87	-0.03	-0.03	0.10
St. deviation	5.40	4.54	6.25	0.29	0.21	3.19
Min	-32.58	-28.79	-25.69	-0.80	-0.80	-12.01
Max	23.28	20.68	37.31	1.50	0.80	11.13
p1	-16.58	-11.27	-14.24	-0.60	-0.50	-6.97
p5	-8.46	-6.42	-9.34	-0.40	-0.30	-5.02
p10	-5.40	-4.28	-6.44	-0.30	-0.30	-3.79
p90	6.60	6.05	8.86	0.20	0.20	4.34
p95	8.57	7.73	11.60	0.50	0.30	5.54
p99	12.78	11.95	17.02	1.00	0.50	7.75

Note: positive (negative) changes in EUR/USD exchange rates correspond to a bilateral depreciation(appreciation) of the euro. Sources: Bloomberg and Banco de Portugal.

Equity prices

Regarding equity prices, the size of the shock was set at 30% (positive or negative).

This variation is unlikely but possible since, for the three equity indices, a change of 30 percent was observed in less than one percent of the observations.

During the period for which we have data, there is no record of a 30 percent change in the S&P 500. However, a very close negative change of 28 per cent was observed. Variations larger than 30 percent have been observed for the EuroStoxx (the largest one being -32.6 percent) and the PSI20 (the largest one being 37.3 percent).

Interest rates

Regarding the interest rates, it seemed reasonable to use parallel shifts in the yield curve of 200 bp and 100 bp (positive or negative). The first figure is clearly above the values used in previous stress tests performed by the Portuguese banks but was chosen because interest rates were at historically low levels in the beginning of 2006.

11 The figures for the stock indices and the exchange rate are thus approximately monthly rates of change.

The second figure more accurately adheres to past experience. In fact, the 3 month euro yield decreased by 60 bp and increased by 100 bp in less than 1 percent of the observations. For the case of the 10 year yield, it changed at least 50 bp in less than one percent of the observations. The maximum change that ever occurred was a 150 bp rise in the 3 month euro yield. The maximum rise in the 10 year yield ever was 80 bp.

The size for a steepening or flattening of the yield curve is 50 basis points (positive or negative). To analyse the steepening and flattening of the curve, we analysed the change in the 10 year yield in those observations for which the 3 month yield changed by less than 10 bp. For these observations, the 10 year yield decreased a maximum of 40 bp and increased a maximum of 50 bp (see Table 2).

Table 2

Pivotal changes in yield curve

Stats	Euro 10 year (pp)
N	71
Mean	-0.01
St. deviation	0.16
Min	-0.40
Max	0.50
p1	-0.40
p5	-0.30
p10	-0.20
p90	0.20
p95	0.30
p99	0.50

Sources: Bloomberg and Banco de Portugal.

Exchange rate

For the euro to dollar exchange rate the suggested size for the shock was 15 percent (positive or negative). The minimum percentage change of the EUR/USD exchange rate was 12, and the monthly change was higher than 7.75 percent in less than one percent of the observations. Once again, for the purpose of the exercise, we used values close to the largest variations.

Implied volatilities

The increase in volatility of market prices creates uncertainty and, therefore, affects the risk management decisions, among others. It also has an impact on the value of a bank's portfolio, especially in terms of the value of a bank's derivatives position. The proposed shock for the volatility of all market prices was 30 percent. The size of this shock is large by historical standards but it is in line with the values proposed by other countries - see Table 3.

Table 3

Implied volatilities using 22-day moving average.

Stats	EuroStoxx 50	S&P 500	Nasdaq 100	Euro 3 month	Euro 10 years	USD/EUR
	(%)	(%)	(%)	(%)	(%)	(%)
N	1876	2907	2314	1729	2907	1572
Mean	24.72	18.24	34.10	13.20	5.40	11.02
Std. Dev.	9.56	5.70	12.58	4.53	1.07	1.84
P1	10.8	10.2	13.9	3.3	3.6	8.2
P5	11.8	10.6	15.1	6.6	4.1	8.6
P10	13.1	11.1	18.3	7.9	4.2	8.9
P90	40.1	25.8	52.8	19.8	6.9	13.7
P95	44.7	29.5	56.9	21.9	7.5	15.0
P99	52.0	33.6	60.4	24.2	8.9	15.8

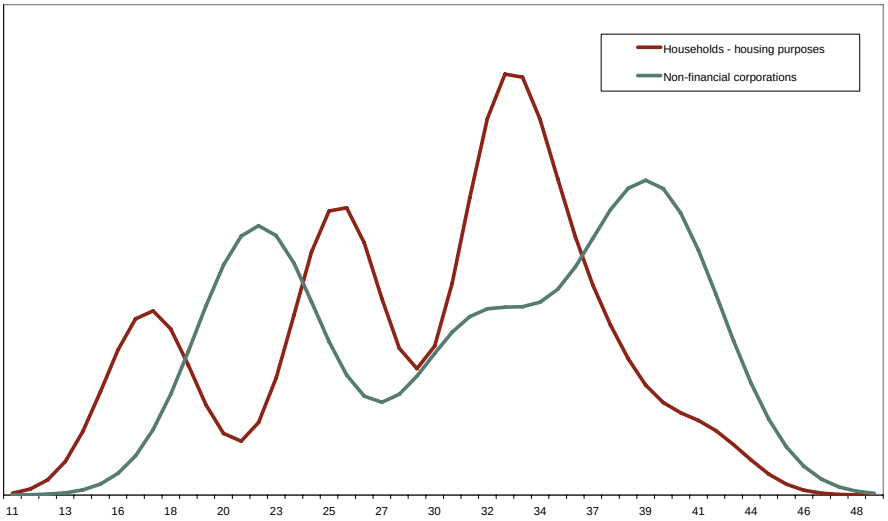
Sources: Bloomberg and Banco de Portugal

4.3 Some characteristics of the banks and pension funds portfolios

The characterization of banks' portfolios allows a better understanding of the results of the stress test. The two most important credit categories of banks are loans to non financial corporations and loans to households for housing purposes. Nevertheless, there are important differences between banks within each category. Regarding credit to non financial corporations, there seems to be two substantially different types of banking groups: for some, this category represents about 40 percent of total assets; for others, it represents only around 20 percent. In terms of loans for housing purposes, there is no clear pattern, with exposures ranging from 15 to around 40 percent of total assets. See Figure 4.5.

Figure 4.5

Empirical distribution of credit to non financial corporations and households (for housing purposes) as a percentage of total assets, for six banking groups.



Note: empirical distribution obtained using a Gaussian kernel.

The corporate loan portfolio is highly concentrated in loans above 50 thousand euros, which is associated with an important exposure of banks towards larger firms (see Figure 4.6). The most important economic sector is the “real estate and services mainly provided to firms”, followed by “construction”, “trade” and “manufacturing”. Nevertheless some banks are particularly exposed to specific economic sectors. For instance, the construction sector represents about 56 percent of the credit portfolio to non financial corporations of one of the banks considered (see Table 4.3).

Figure 4.6

Credit to the corporate sector granted by six banking groups, by loan size, as of December 2005.

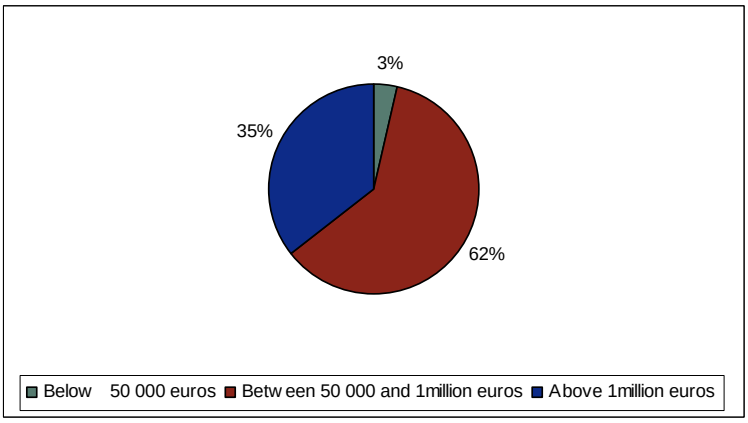


Table 4.3

Credit to the corporate sector granted by the six banking groups, by economic sector, as of December 2005.

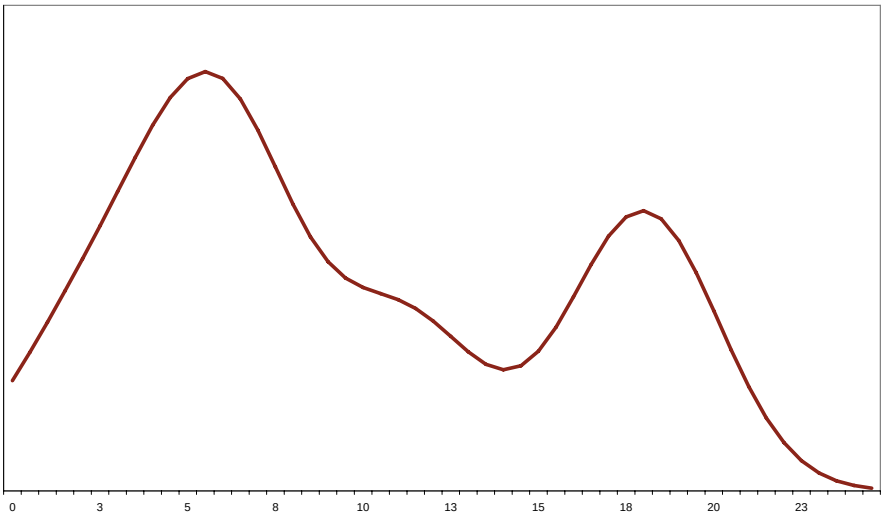
	Trade	Construction	Energy	Manufacturing	Real estate & services provided mainly to firms	*of which:* *Real estate activities*	*Other services provided mainly to firms*	Transportation	Other
Average	15.1	19.7	2.6	14.3	32.5	*17.0*	*13.3*	7.1	8.9
Maximum	20.1	55.5	5.5	18.9	36.3	*24.3*	*18.3*	11.4	10.3

Note: the average is computed weighting the exposure of each institution to each sector by its total exposure to the corporate sector. The "Other" sector results from the sum of all other sectors not individually presented.

As for the securities portfolio, shares held by banks represent less than 4 percent of total assets. There is some heterogeneity between banks as some banks report having no shares in their securities portfolio. In turn, on average, bonds represent a higher share in total assets of about 10 percent. The distribution is highly concentrated in two quite different values: for most banks bonds account for roughly 5 percent of total assets but for others these financial assets account for almost 20 percent of total assets (see Figure 4.7).

Figure 4.7

Empirical distribution of bonds held as a percentage of total assets, for six banking groups.

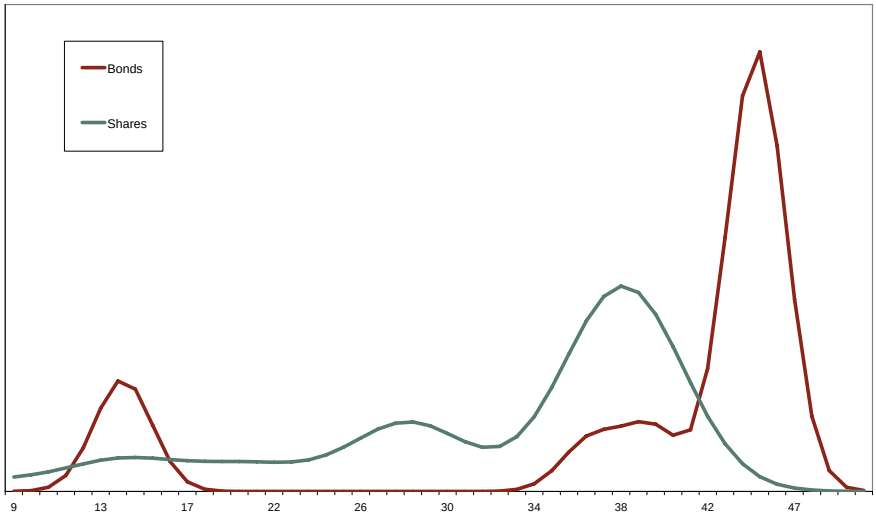


Note: empirical distribution obtained using a Gaussian kernel.

Most pension funds do not have a representative amount of deposits in their portfolios. In fact, with one exception, bonds are the most important asset held by pension funds. Shares also represent a sizeable part of the pension funds portfolio (see Figure 4.8.). As a consequence, large fluctuations in equity prices may yield an important impact in the value of total assets of pension funds. This implies that at least for some banks, the exposure to equity risk is large. These features help explain the results of the stress test exercise, namely those of Sections 4.4 and 4.5.

Figure 4.8

Empirical distribution of shares and bonds as a percentage of pension funds' total assets, for five banking groups.



Note: empirical distribution obtained using a Gaussian kernel. One banking group not included.

4.4 Scenario analysis: main results

The estimated impacts of shocks were measured against banks' December-2005 risk weighted capital adequacy ratio (CAR ratio)[12] considering the impact of each risk factor shock on regulatory capital. Consequently, the impacts are measured in percentage points of the CAR ratio.

Figures 4.9 and 4.10 present the annual and the cumulative impact of all risk factors on the CAR ratio for the three scenarios considered[13]. The impacts result from credit risk and market risk shocks on the bank portfolio, considering the impact on shares of quoted companies, plus market risk impacts on the bank employees' pension funds. Impacts are measured in percentage points of CAR ratio.

As expected, impacts are very small in the baseline scenario. The disruptive adjustment stress scenario produces the highest impacts of all scenarios, being mostly concentrated in 2006 because of the strong decrease in equity prices that was assumed (-30 per cent). In general, market risk factors have two effects on regulatory capital: via the bank portfolio and, indirectly, via the bank employees' pension funds. Consequently, a strong

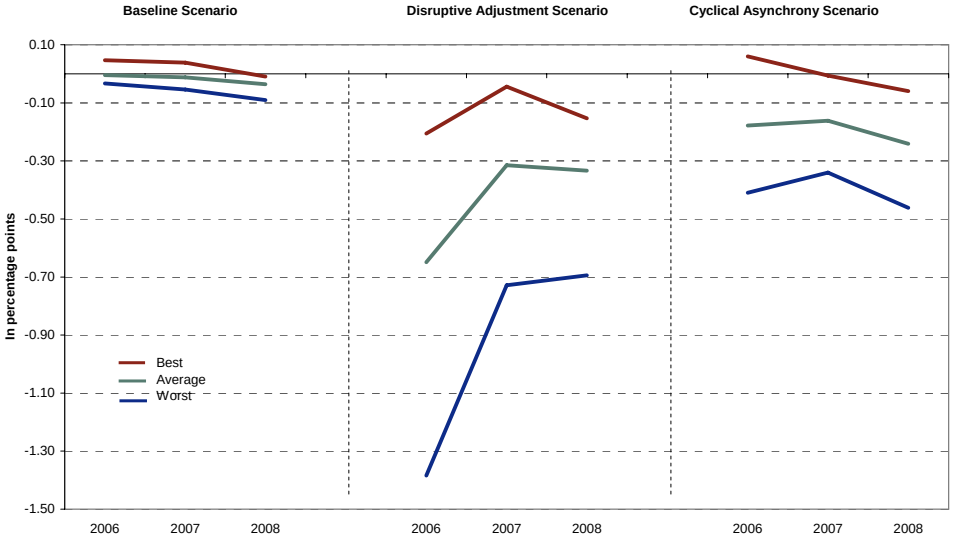
12 The risk weighted capital adequacy ratio (CAR ratio) is defined by $\frac{\text{Regulatory Capital}}{\text{Own Fund Requirements} * 12.5}$. All impacts are measured in percentage points, assuming the denominator constant at the level of December 2005.

13 The average impact is computed weighting the impact of each institution by the value of own fund requirements.

shock on share prices would impact significantly the banks performance. In the cyclical asynchrony stress scenario, impacts have roughly the same magnitude each year.

Figure 4.9

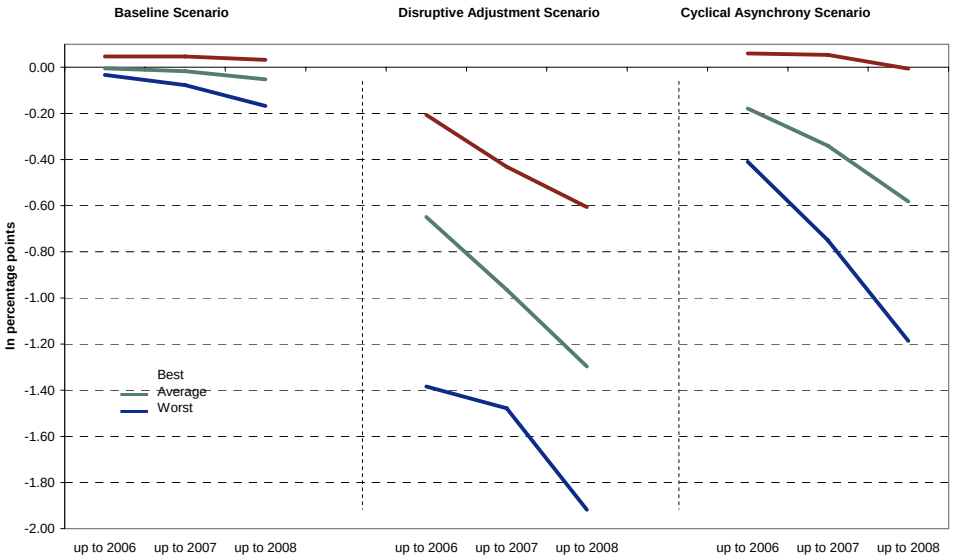
Impact of all risk factors on the CAR ratio, by year.



Note: includes the impact of credit risk and market risk on the bank portfolio plus the impact of market risk factors on the bank employees' pension funds. In percentage points of the CAR ratio.

Figure 4.10

Cumulative impact of all risk factors on the CAR ratio.



Note: includes the impact of credit risk and market risk on the bank portfolio plus the impact of market risk factors on the bank employees' pension funds. In percentage points of the CAR ratio.

Table 4.4 presents the decomposition of the total impact on each of the risk factors considered[14]. As mentioned, in the disruptive adjustment scenario, the biggest impact on CAR ratio results from the shock on financial markets. The adverse performance of equity markets hinges on banks' financial assets portfolios and, most notably, on the value of the assets held by their pension funds. At end-2005, four pension funds were outside the regulatory corridor[15]. These are mostly large pension funds, which invest more in equity assets, thus making them more vulnerable to negative shocks in equity markets. In the cyclical asynchrony scenario, where probabilities of default increase significantly due to the combination of the negative growth of GDP with the strong increase in interest rates, credit risk is the most important risk factor. Changes in the exchange rate and interest rates do not have a significant impact in all scenarios.

Table 4.4

Total impact of each risk factor on CAR ratio

Baseline	Expected Loss	Credit Growth	Share prices	Interest rates	Exchange rates	Pension Funds	TOTAL
Average	0.04	-0.05	0.00	-0.02	0.02	-0.04	-0.05
Best	0.12	-0.02	0.00	0.01	0.05	0.00	0.03
Worst	0.02	-0.12	0.00	-0.07	0.00	-0.20	-0.17

Disruptive adjustment	Expected Loss	Credit Growth	Share prices	Interest rates	Exchange rates	Pension Funds	TOTAL
Average	-0.25	-0.05	-0.22	0.03	-0.04	-0.77	-1.30
Best	-0.14	-0.02	0.00	0.28	0.00	0.00	-0.61
Worst	-0.66	-0.13	-0.43	-0.14	-0.09	-1.56	-1.92

Cyclical asynchrony	Expected Loss	Credit Growth	Share prices	Interest rates	Exchange rates	Pension Funds	TOTAL
Average	-0.43	0.00	0.00	-0.10	0.02	-0.06	-0.58
Best	-0.23	0.00	0.00	0.23	0.05	0.00	-0.01
Worst	-1.06	-0.02	0.00	-0.33	0.00	-0.15	-1.19

Solvency ratio

Based on the information of the whole exercise, i.e., the banks' best estimates of the full set of accounts (both Balance sheet and Profit and Loss items), it is possible to project the solvency ratio over the three-year period. These estimates, contrarily to the above

14 In the case of the average, as factors' impacts are additive, we can interpret these values as contributions to the total impact. It should be born in mind that additivity does not hold in the "Best" and "Worst" cases.

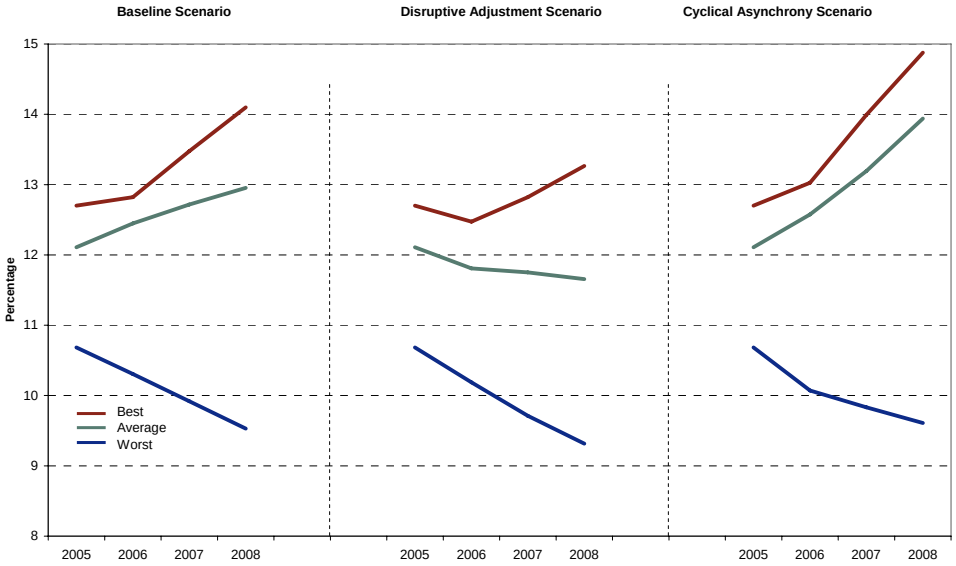
15 IAS 19 permits credit institutions to apply the "corridor approach" to actuarial gains and losses arising from its defined benefit pension plans. The "corridor approach" allows banks to recognize only a portion of those gains and losses as income or expense if the net cumulative unrecognized actuarial gains and losses at the end of the previous reporting period exceeds the greater of: 10% of the present value of the defined benefit obligation at that date (before deducting plan assets); and 10% of the fair value of any plan assets at that date.

mentioned analysis of shocks, take into account also the accrual of income not impacted directly by shocks. On average, the solvency ratio increases in the baseline and the cyclical asynchrony scenarios, while it decreases in the disruptive adjustment scenario (Figure 4.11).

All institutions present a solvency ratio higher than 9 per cent throughout the projected horizon and under all scenarios.

Figure 4.11

Solvency ratio considering the whole exercise.



An additional ad hoc robustness exercise was conducted imposing a multiplicative shock on default probabilities. This additional exercise allows for the possibility of even more extreme and unlikely scenarios.

In this additional exercise, all probabilities of default were multiplied by a factor of 1.2 (20 percent increase) and 1.5 (50% percent increase). This shock would have an impact on CAR ratios. The CAR ratio of each bank, in a given date, is defined by $CAR_t = \frac{RC_t}{OFR_t} \frac{1}{12.5}$, where RC means Regulatory Capital and OFR means Own Fund Requirements. An increase in Expected Losses, defined by the product between Probability of Default and Loss Given Default, has a negative impact on both RC and OFR values. The regulatory capital decreases by the additional expected loss, after considering both taxes and retained profits, up to the point operating profits are zero. Taxes and retained profits were not taken into account when operating profits lie below zero.

The own fund requirements decrease by the additional expected loss weighted in accordance to the category of credit considered. For instance, credit to corporations was weighted 100 percent, and credit to households for housing purposes was weighted 50

percent. It was also taken into account that the growth of each credit category depends on the scenario under consideration.

As expected, the average solvency ratio of the system decreases as probabilities of default increase (see Table 4.5). However, the solvency of the system proves to be such that quite severe shocks can be absorbed without reaching the regulatory minimum for the solvency ratio.

Table 4.5

Projected solvency ratio, considering the whole exercise, imposing shocks on default probabilities.

imposing a shock of 1.2 on the Expected Losses values for 2006 to 2008

	Baseline				Disruptive adjustment				Cyclical asynchrony			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
Average	12.1	12.4	12.7	12.9	12.1	11.7	11.7	11.5	12.1	12.5	13.1	13.8
Best	12.7	12.8	13.4	14.1	12.7	12.3	12.8	13.1	12.7	13.0	13.9	14.8
Worst	10.7	10.1	9.8	9.4	10.7	10.0	9.5	9.0	10.7	9.9	9.6	9.3

imposing a shock of 1.5 on the Expected Losses values for 2006 to 2008

	Baseline				Disruptive adjustment				Cyclical asynchrony			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
Average	12.1	12.3	12.6	12.8	12.1	11.6	11.5	11.3	12.1	12.4	13.0	13.7
Best	12.7	12.7	13.4	14.0	12.7	12.3	12.5	12.8	12.7	12.9	13.8	14.7
Worst	10.7	9.9	9.5	9.2	10.7	9.7	9.1	8.6	10.7	9.6	9.2	8.8

Operating profits

As mentioned, banks were asked to project their Profit and Loss accounts under the three scenarios. Table 4.6 presents the evolution of projected operating profits in the three scenarios, as a percentage of 2005 operating profits. In general, the less unfavourable stress scenario for banks is the cyclical asynchrony one. Although this scenario considers the highest probabilities of default, it also considers the largest increase on both short-term and long-term interest rates. Hence, the positive impact on profits from an increase in interest rates proves to be larger than the negative impact arising from higher probabilities of default. It is worth mentioning that the magnitude of the decrease of interest rates in the disruptive adjustment scenario is lower than the increase in the cyclical asynchrony scenario. Given the level of interest rates in 2005, there is a binding lower bound to the remuneration of customer deposits, in particular in customer demand deposits. In fact, these deposits typically pay very low interest rates (on average demand deposit interest rates were around 0.50 percent in 2005), so that in the disruptive adjustment scenario most institutions reflect only partially the change in the money market interest rate. On the other hand, banks do not face this constraint when transmitting rises in market interest rates to customer deposits' interest rates. This fact creates an asymmetry in terms of the remuneration of customer deposits.

Table 4.6

Operating profits as a percentage of December 2005 operating profits.

	Baseline			Disruptive adjustment			Cyclical asynchrony		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
Average	95.4	99.2	104.1	49.4	48.9	39.7	102.8	102.5	100.0
Best	105.0	122.0	133.5	65.5	79.7	70.0	116.8	131.4	137.9
Worst	55.0	73.6	75.0	15.1 (*)	12.9 (*)	1.3 (*)	70.5	72.3	54.3

Note: (*)These results are dominated by the reporting bank's assumptions underlying the interest accrual. As a consequence, there is a clear underestimation of the operating income in this case. Notwithstanding, the solvency ratio for this institution remains above the minimum requirement.

Assessment of the implications under stress scenarios to banks' liquidity

All institutions have in place contingency procedures to deal with market liquidity constraints, namely including a hierarchy of extraordinary funding sources to fulfil possible escalating squeezes. All institutions recognised that a downgrade of the Portuguese Republic rating, if sizeable, should primarily impact on the price they are able to issue debt in international markets (money market and debt securities market). All institutions' responses are explicit in giving much attention to being prepared in advance for extreme market liquidity situations, namely by keeping interbank credit lines, a buffer of liquid assets represented by interbank deposits and highly liquid securities, procedures to mobilize "liquidity" and other classes of securities and continuous tapping of a diversified set of markets for different instruments and investor profiles. Most of them highlighted that the most stressful situations would arise from the drying up of international capital markets, rather than country-specific issues, for instance those related with the rating of the Republic.

The assessment differed somewhat among institutions depending on their liquidity profile at the assessment date. One institution holds a very significant structural pool of liquid assets and quantified a 1-notch downgrade of the Republic as having only minor impacts on its funding costs (4 to 5 basis points in the medium/long term debt segment, 1 to 2 basis points in the short-term debt securities segment and nil in the money market). A 2-notch downgrade would triple the increase in debt securities' costs (12 to 15 basis points in the medium/long term debt segment, 3 to 6 basis points in the short-term debt securities segment), while implying possible quantitative reductions in available credit lines.

Another institution with a policy of keeping an ample liquidity surplus in the short-term (even though with a structural funding gap) reported its usual practise of quantification of the implications of severe market liquidity shortfalls. In particular, it reported that, under the assumption of complete inability to access international capital markets for a continuous period of 1 year, the discount of securities in regular monetary policy operations, the reduction of interbank investments, the prudent "liquidification" of securities currently non-eligible for monetary policy operations (namely by imposing prudent *hair-cuts* over the market value and by excluding the amount of non-recurrent

customer deposits from available liquidity) would be sufficient to cover all maturing liabilities and to generate a surplus of over 20 percent of all additional liquidity requirements.

4.5 Sensitivity tests: main results

The sensitivity analysis aims to assess the impact of large and instantaneous shocks in risk factors, holding other risk factors constant. Three risk factors were examined: interest rate risk (a parallel shift in the yield curve and a steepening or flattening of the yield curve), equity price risk and foreign exchange rate risk (euro/US dollar).

The sensitivity-based stress tests were rooted on historical data on equity prices, short and long term yields of government debt from countries that currently are members of the European Monetary Union, the EUR/USD exchange rate (in euros per dollar), and implied volatility of equity prices, exchange rates and interest rates. The proposed shocks may be improbable but justifiable considering past data, standard industry practices and/or other FSAPs performed in other countries. The size and nature of the shocks are described in Box 1 and Table 4.2.

The impacts of the sensitivity tests on the banks portfolio are presented in Table 4.7.

Table 4.7

Sensitivity tests. Impacts on CAR ratio.

	Joint movement of interest rates				Pivotal movement of the 10-year interest rate		Change in the EUR/USD exchange rate		Change in equity prices		Change in implied volatility in all financial market prices	
	3-m: +100 bp	3-m: -100 bp	3-m: +200 bp	3-m: -200 bp								
	10-Y: +50 bp	10-Y: -50 bp	10-Y: +100 bp	10-Y: -100 bp	+50 bp	-50 bp	+15%	-15%	+30%	-30%	+30%	-30%
Average	-0.04	0.03	-0.08	0.06	-0.01	0.02	0.02	-0.03	0.24	-0.25	0.00	0.00
Best	0.06	0.17	0.13	0.36	0.03	0.07	0.11	0.05	0.44	-0.11	0.01	0.00
Worst	-0.17	-0.06	-0.32	-0.11	-0.06	-0.04	-0.07	-0.11	0.11	-0.48	0.00	-0.01

Results suggest that banks can absorb these individual shocks well. Equity price risk produces the strongest effects in relative terms (-0.48 percentage points for the worst performer). Interest rate risk yields the second largest effect especially in the case of a large interest rate hike affecting both short and long rates (-0.32 percentage points for the worst performer). The impact of foreign exchange risk is minor and that of volatility risk is negligible.

Finally, the results on sensitivity tests on the balance sheet of the bank employees' pension funds (defined-benefit schemes only) are presented in Table 4.8. The metric used is that of net assets (assets minus liabilities) over total liabilities. This table differs from the previous one also because shocks to the actuarial discount rate are incorporated in the shocks that cause a joint movement in rates.

There is a strong sensitivity to the equity price shock and, to a lesser extent, to a downward change in the yield curve. The relatively strong sensitivity to downward changes in the yield curve results from the duration mismatches between pension

scheme assets and liabilities. This causes a lowering of rates to have a negative effect on net asset values, which is primarily driven by an increase in the value of liabilities (as a result of the lowering of the actuarial discount rate) which outweighs any increase in asset values (as a result of the lowering of the short- and long-term interest rates). This explains the difference in the signs of the results from the joint movement of interest rates and the pivotal movement of 10-year interest rate.

Table 4.8

Banks' employees Pension Funds. Net value changes (assets minus liabilities) as a percentage of total liabilities.

	Joint movement of interest rates				Pivotal movement of the 10-year interest rate		Change in the EUR/USD exchange rate		Change in equity prices		Change in implied volatility in all financial market prices	
	3-m: +100 bp 10-Y: +50 bp actuarial discount rate: +25bp	3-m: -100 bp 10-Y: -50 bp actuarial discount rate: -25bp	3-m: +200 bp 10-Y: +100 bp actuarial discount rate: +50bp	3-m: -200 bp 10-Y: -100 bp actuarial discount rate: -50bp	+50 bp	-50 bp	+15%	-15%	+30%	-30%	+30%	-30%
Average	3.16	-3.41	6.33	-6.94	-0.45	0.40	0.55	-0.55	9.34	-9.34	-0.08	0.09
Best	4.00	-2.21	7.83	-4.02	-0.12	0.94	1.41	-0.06	14.88	-5.26	0.63	2.44
Worst	2.69	-4.46	6.18	-9.17	-1.08	0.09	0.06	-1.41	5.26	-14.88	-2.76	-0.50

The sensitivity analysis confirms the results of the scenario-based analysis. In general, share prices shock is the most relevant one. Interest rate and exchange rate risk prove to have less importance as most banks have small open positions.

5 Additional stress test exercises

5.1 Stress testing exposures to non financial corporations

In the context of the Portuguese FSAP, separate exercises were carried out consisting of (i) an assessment of the loan loss distribution for non financial corporations and (ii) the interactions between real and financial variables. Exercise (ii) is the object of Box 2. This section presents in detail approach (i), including the methodology and the main results of using the credit default model described in Section 4.1.1 and credit register data to obtain the distribution of total losses of the Portuguese credit portfolio to non-financial firms. [16] The entire portfolio of credit to non financial firms was used; therefore, a stress test to the complete set of Portuguese banking groups was performed.

The distribution of losses was determined making use of Monte Carlo experiments. In order to perform the simulations under alternative macroeconomic scenarios – the baseline, the "disruptive adjustment" and the "cyclical asynchrony" scenarios of Section 2 – simplifying assumptions regarding the evolution of the portfolio characteristics were adopted. A characterization in terms of specific dispersion ratios and impact on total exposure of the maximum loss one should expect at a given probability level was then undertaken. Additionally, a calculation of the distribution of the Capital Adequacy Ratio under simplifying assumptions about the behaviour of losses in loans to non-financial corporations was performed. This approach allows for an assessment of the ability of the Portuguese financial system as a whole to accommodate macroeconomic shocks propagating through credit to non-financial firms.

Several interesting conclusions can be drawn from this analysis. For instance, with a 95 percent probability, losses represent less than 1.8 percent of total exposure in 2008 for the baseline case. At the same confidence level, the comparable value is 3 percent for the disruptive adjustment scenario and 3.4 percent for the cyclical asynchrony case.

The previous figures suggest that the cyclical asynchrony stress scenario is more adverse than that of the disruptive adjustment case. Indeed such is the case. At the end of the simulation period, the expected loss for the cyclical asynchrony case is roughly 25 percent higher than the disruptive adjustment case. In terms of the distribution, the same conclusion holds. For instance, there is a 96 percent probability that total losses in 2008 are less than 1.9 percent of total exposure in the baseline case. That probability in the disruptive adjustment stress scenario is 50 percent. The figure for the cyclical asynchrony case is just above 5 percent. These conclusions are in line with those previously arrived at in Sections 3 and 4, where credit risk proved to be the most important risk factor in the cyclical asynchrony scenario.

16 See Antunes, Ribeiro e Antão (2006) for a description of the credit default model used in the exercise.

This analytical instrument makes the analysis of specific percentiles of the CAR distribution for the overall banking system possible. This distribution has to be interpreted carefully as it reflects a situation where the macro risk factors are assumed to impact exclusively default rates of credit to non-financial corporations. The results show that the system as a whole is resilient to extreme macroeconomic outcomes. For instance, the probability that the aggregate CAR falls below 9.9 percent is 0.5 percent.

5.2 The data and binary response model

Data from two sources were used: the credit data from the *Central de Responsabilidades de Crédito* (CRC), which is the Portuguese credit register; and the *Estatísticas Gerais* (EG) database for the economic sector information. A sample of firms was classified in terms of total exposure (in a total of 4 classes, with larger firms in terms of credit exposure having higher representativeness in the sample), and was stratified by economic sector (in a total of 15 different economic sectors). The "loan" was set as the statistical unit of observation, since this is the relevant concept of interest when looking at default events in particular loans, and was defined as the bilateral credit relationship between a firm in the sample and a single credit institution. Note that this definition does not necessarily correspond to a single loan, as any given firm may have contracted several loans with the same credit institution. The CRC monthly data were transformed into quarterly data. The sample includes almost 2 million observations and ranges from 1995Q1 to 2004Q4.

A binary response model with a probit specification was estimated, in which the "default event" was defined as occurring whenever positive past due amounts are observed in three consecutive months (including the month under analysis), and the amount past due three months before was zero. The loan is then removed from the sample until either the loan disappears from the CRC or the impaired credit amount returns to zero.

The model includes regressors at the loan, firm, sector and aggregate levels. At the loan level, two dummy variables are used. The first is an indicator of the event that, not including the loan under observation, the loan's obligor has on average defaulted on more than half of its loans during the current quarter. The second variable indicates whether the firm has defaulted on credits other than the loan under observation in the current quarter.

At the firm level, categorical variables for the economic sector, the firm's total credit and the total number of loans of each obligor (top coded to 5 loans) were also introduced.

Unemployment, short-term nominal interest rates, and deviations of GDP from trend were selected as macroeconomic determinants, with one, two, three and four lags.

In addition, several other aggregate variables (a dummy for the euro introduction in 1999 and its interaction with the interest rate; interaction terms of contemporaneous macroeconomic variables with both the economic sector and the exposure dimension class; and quarterly seasonal dummies) to account for the macroeconomic environment and its interaction with the firm-level characteristics were included.

The probit model has a robust in-sample performance, with power around 86 percent. Out-of-sample performance is likely to be acceptable as well, as suggested by the fact that estimations with much smaller samples yielded similar results. Out-of-time tests are more difficult to carry out in view of the fact that only one entire business cycle is included in the sample.

5.3 Estimating the loss distribution

Given a credit portfolio and a macroeconomic scenario, the estimated model can be used to randomly generate residuals for all loans of the portfolio. Each loan is then classified as having defaulted or not according to the binary response rule. Summing all "defaulted" loans, an aggregate measure of loan defaults for that particular experiment can be reached.[17] Repeating this procedure a given number of times generates a Monte Carlo estimate of the entire loan loss distribution.

One methodological issue is worth mentioning. The sample is stratified by economic sector and credit exposure class. All the firms in the largest exposure class are included, but firms in smaller exposure classes are sub-represented. Due to software limitations, it is not possible to use the entire portfolio to compute all the relevant regressors and then apply the estimated model in order to simulate losses. The procedure adopted was to use the estimation sample, and then oversample the sub-represented classes and sample the largest exposure class so as to replicate the features of the whole portfolio in terms of exposure classes. In view of the very large number of observations used in all classes, the procedure should not introduce significant bias in calculating the distribution of losses using Monte Carlo simulations. This is corroborated by the coincidence between average losses of these Monte Carlo simulations, and the average loss computed using exclusively the economic sector and exposure class information applied to the whole portfolio, a much lighter approach in terms of computational requirements.

5.4 Portfolio

For the sake of feasibility, the banks' portfolio of credit to non-financial corporations was assumed to remain broadly unchanged in the course of the simulation. This means that, to simulate credit losses, the regressors in the credit default model other than the macroeconomic variables are assumed to be those of the banks credit portfolio in the last quarter of end-2004. This hypothesis is naturally subject to criticism, as it ignores the endogenous change of the portfolio as the macroeconomic environment changes, firms default, and new firms and loans enter the portfolio. An alternative approach would be to exclude loans as default occurs (and also looking at the respective firm) and then look at the remaining portfolio. In the absence of a model describing the characteristics of new firms and loans, however, this approach is likely to bias the results in unpredictable ways.

17 Notice that the aggregate default amount is the total amount of loans that are impaired, and not just the defaulted part. This should not make much difference to considering only the defaulted part, since, in most cases, after some time banks have to classify the entire loan as defaulted.

An analysis of the portfolio evolution in terms of exposure class and economic sector shows high stability over time for the whole Portuguese credit portfolio to non-financial firms. Therefore, the portfolio structure was set to remain constant (implicitly assuming that the firms and loans leaving the portfolio do not differ significantly from entrant firms and loans) and the impacts on the loan loss distribution are interpreted as the isolated effect of macroeconomic factors. Since a constant loss given default (LGD) measure was used to translate default rates into actual losses, the expected loan loss as a fraction of total credit (in percentage deviations from the baseline) can be obtained from Table 4.1.

The cyclical asynchrony scenario induces higher losses at the end of the simulation horizon, while the disruptive adjustment produces a sharper initial rise.

A portfolio that mimics the structure of the Portuguese loans to non-financial firms as of 2004Q4 was used to perform 10,000 experiments for each year and scenario in the simulation horizon.

Figures 5.1 to 5.3 present the yearly total loss as a percentage of the total exposure amount. This is a relative Value-at-Risk measure. The $(1-\alpha)\times 100$ percent VaR is the threshold above which losses will lie $\alpha \times 100$ percent of the time. It is important to give a precise meaning to VaR measures in the context of stress tests. To simplify matters, let us assume that macroeconomic stress scenario X will materialize every year with probability p, and an alternative, more benign scenario will be the outcome with probability $1-p$. In the context of a stress test, *p* is necessarily small. This means that the ex ante probability attached to losses being larger than the $(1-\alpha)\times 100$ percent VaR under scenario X is $\alpha \times p$. If, say, p is 10 percent and α is 0.05, then this probability is 0.005, an event likely to occur once every 200 years. It should also be noted that the VaR of loans to non-financial firms does not add up with the VaR of loans, for instance, to households. Therefore, it would be incorrect to add VaR measures for loans to the corporate sector under scenario X to VaR measures for loans to households under the same scenario.

Figure 5.1

Distribution of the loss as a percentage of the exposure to non-financial firms, 10,000 replications, baseline scenario.

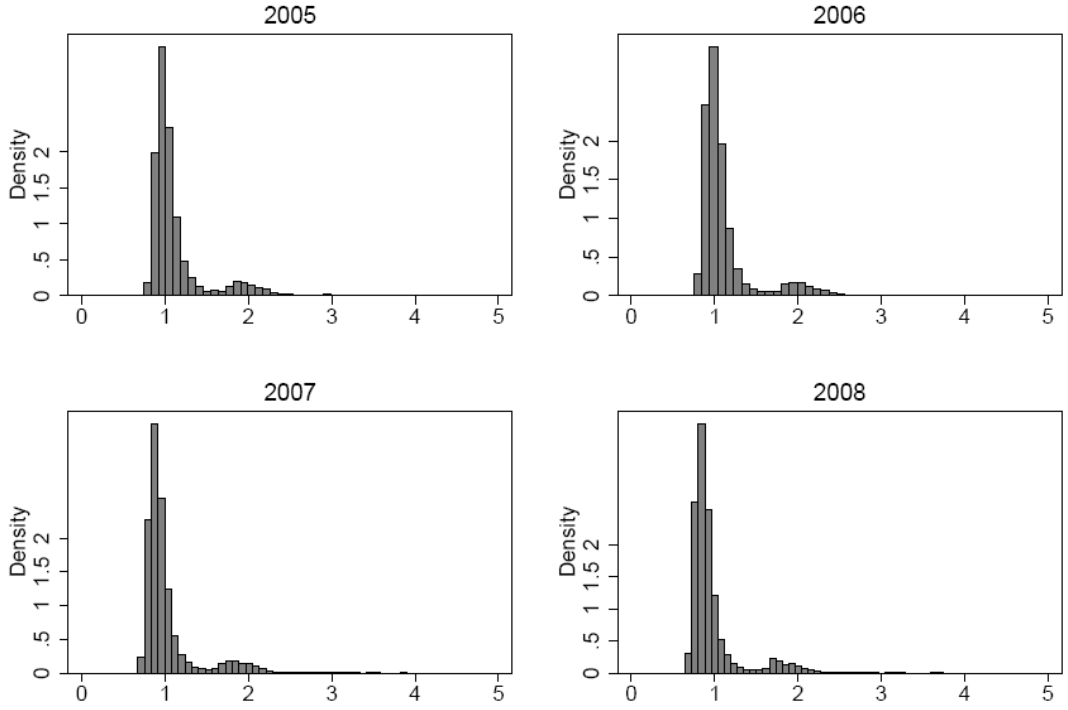


Figure 5.2

Distribution of the loss as a percentage of the exposure to non-financial firms, 10,000 replications, disruptive adjustment scenario.

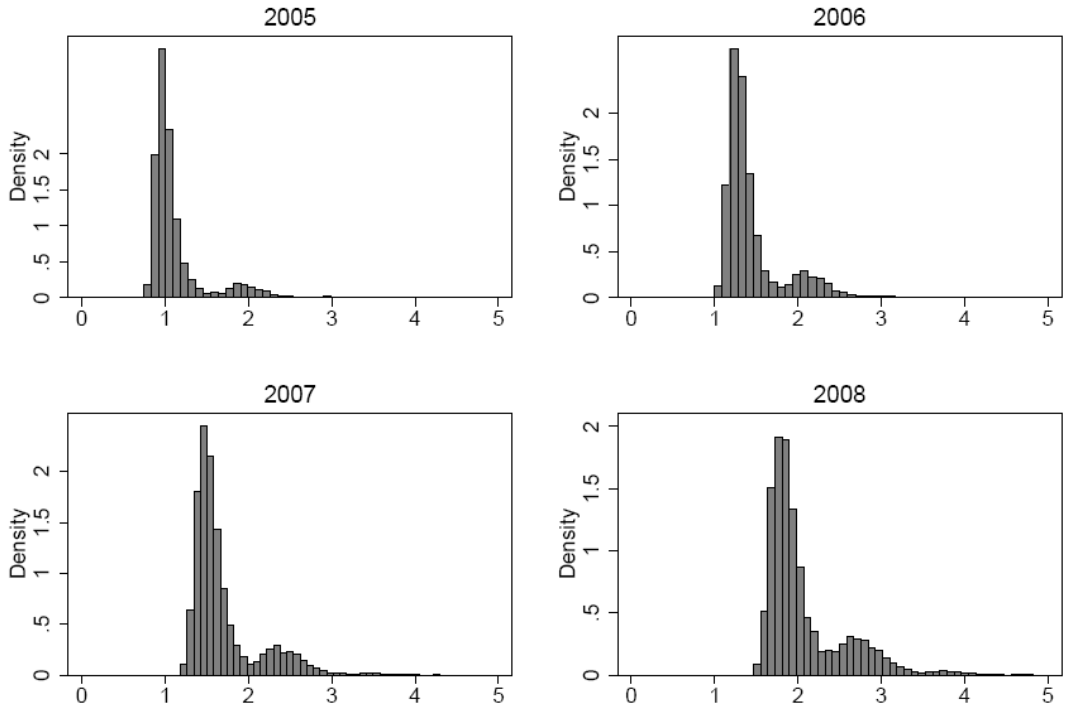


Figure 5.3

Distribution of the loss as a percentage of the exposure to non-financial firms, 10,000 replications, cyclical asynchrony scenario.

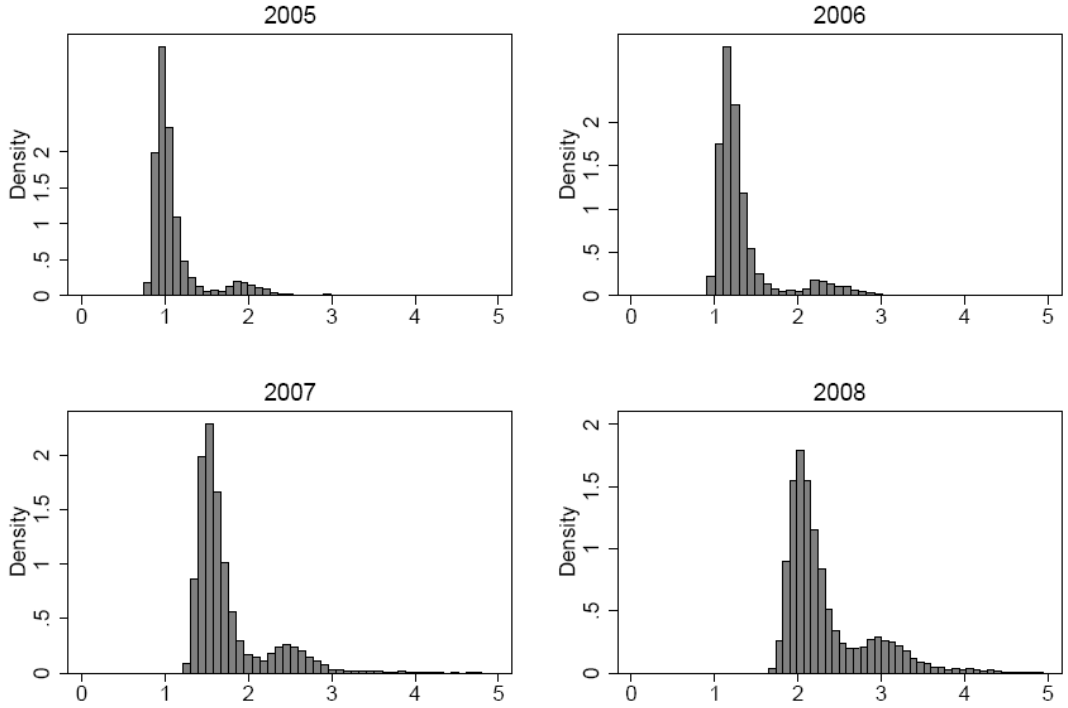


Table 5.1.

Percentiles of the loss, 10,000 replications. All values in yearly percentage of total exposure to non-financial firms.

		2005	2006	2007	2008
Baseline	p1	0.8	0.8	0.7	0.7
	p5	0.9	0.9	0.8	0.7
	p95	2.0	2.0	1.9	1.8
	p99	2.3	2.4	2.2	2.2
Disruptive adjustment	p1	0.8	1.1	1.3	1.6
	p5	0.9	1.1	1.3	1.6
	p95	2.0	2.3	2.6	3.0
	p99	2.3	2.7	3.1	3.8
Cyclical asynchrony	p1	0.8	1.0	1.3	1.8
	p5	0.9	1.0	1.4	1.9
	p95	2.0	2.4	2.7	3.4
	p99	2.3	2.8	3.4	4.1

Turning to the VaR results, in the baseline scenario the total loss in 2005 is estimated to be less than 2 percent of the aggregate exposure to non-financial corporations with a 95 percent probability (Table 5.1) and, even more conservatively, less than 2.3 percent of the

exposure would be lost in 2005 with a 99 percent confidence level.[18] In this scenario the decrease of expected losses in the simulation horizon is accompanied by a decrease in losses in the extreme percentiles of the distribution.

Figure 5.1 emphasizes the fact that the distribution of the baseline scenario does not change much along the simulation horizon. Figures 5.2 and 5.3 show that the distribution shifts to the right during the simulation horizon in the stress scenarios. Given that the model is difficult to interpret if looking only at the regression coefficients, it is instructive to look at the evolution of the macroeconomic variables under the different scenarios and then observe how the distribution changes.

From 2005 to 2006, the main differences between the baseline and the disruptive adjustment scenarios are the sharp fall in output growth and the fall in the interest rate, while the main differences between the baseline and the cyclical asynchrony scenarios are the sharp rise in the interest rate and the fall in output growth. In other words, relative to the baseline the two stress scenarios have output falling – but the interest rates change in opposite directions. The width of the 90 percent confidence interval changes from 1.1 pp in 2005 to 1.2 and 1.4 pp in 2006 for the disruptive adjustment and the cyclical asynchrony case, respectively. This behaviour suggests that the interest rate has a spreading out effect in the distribution (because the width of the 90 percent confidence interval increases markedly).

In the last two years of the simulation period (2007 and 2008), the macroeconomic environment differs between the two stress scenarios essentially in terms of the interest rate. The expected losses for 2008 for the cyclical asynchrony scenario are roughly 25 percent higher than those of the disruptive adjustment. The cyclical asynchrony case also shows a larger degree of dispersion; for instance, the 90 percent confidence interval has a width of 1.5 pp, against 1.4 pp for the disruptive adjustment case. This suggests that a higher interest rate shifts the distribution to the right, and also spreads it out.

A last remark is on the relationship between losses in the different scenarios. For the disruptive adjustment scenario, the median loss in 2008 is 1.9 percent of total exposure to non-financial corporations. Such loss corresponds to the percentile 96 in the baseline case. This means that there is a 96 percent probability that the loss is less than 1.9 percent of total exposure to non-financial corporations in the baseline case, while that probability in the disruptive adjustment stress scenario is only 50 percent. The figure for the cyclical asynchrony case is even less, just above 5 percent. This example implies that, with respect to the distribution, the disruptive adjustment is much more benign in terms of losses than the cyclical asynchrony scenario.

In brief, relative to the disruptive adjustment, the higher interest rate of the cyclical asynchrony scenario widens the distribution and shifts it to the right.

---

18 In a somewhat different context (using a macroeconomic reduced-form credit risk model) and for the Finnish 2003Q2 credit portfolio to non financial firms, Virolainen (2004) reports a comparable figure of 1.81 percent.

The usual criticisms apply to this exercise. The credit default model omits important dimensions that might help explain default. This was a consequence of the lack of comprehensive data on the firms' balance sheets. Other working hypotheses, regarding in particular the assumption that the portfolio structure remains unchanged throughout the projection exercise, may also be insufficient or inadequate. The results should therefore be interpreted cautiously.

5.5 Distribution of the Capital Adequacy Ratio due to losses in credit to non-financial firms

In order to gauge the impact of the distribution of losses presented in the previous section, a simple experiment was carried out based on known 2005 figures on capital adequacy and total exposure to non-financial corporations. Afterwards, changes in own funds due to loss variability were estimated and these estimates were then used to obtain the distribution of the Capital Adequacy Ratio (CAR). Several assumptions had to be made in this respect.

1. The projections for the simulation horizon are based on 2005 figures using known data from various sources.
2. The portfolio essential features remain unchanged throughout the simulation period.
3. The distribution of losses is identical to that described in Figures 5.1-5.3 under the different macroeconomic scenarios, even though the underlying bases for calculating data (corporate sector credit in 2005) differ slightly for a set of technical reasons.
4. Loss variability is the sole source of variability during simulations.
5. The changes in capital adequacy requirements stemming from changes in the probability of default are neglected and only losses are taken into account.

Consolidated own funds of Portuguese banks totalled 23.8 thousand million euros by the end of 2005, while own funds requirements were 16.8 thousand million euros. The overall CAR was thus 11.3 percent, standing above the Basel II Accord minimum level (8 percent), implying that the probability of an unexpected loss larger than own funds during one year should be lower than 0.5 percent.

This exercise aimed at answering the following question: what is the distribution of the CAR, given that the overall characteristics of the credit portfolio to non-financial firms are fixed, all risk-bearing exposures are constant except credit to non-financial firms, and the macroeconomic environment is changing according to a given scenario?

To answer this question, the expected value of own funds was assumed to remain fixed at the 2005 level minus the expected change in each scenario relative to the baseline in 2005. Thus, any loss impacts on own capital directly. Table 5.2 presents the results of the

exercise. The probability that, in 2008, the CAR turns out to lie below 10.8 percent due to losses in loans to non-financial firms is just 0.5 percent in the baseline. In the disruptive adjustment scenario, the 0.5 percent CAR level at the end of the simulation horizon is 10.1 percent. The interpretation of this number is as follows. This is an upper bound of the CAR that the financial institutions as a whole would have with probability 0.5 percent if they assumed own funds, capital adequacy requirements and total exposure did not vary from their 2005 level (or all varied in the same proportion).

Table 5.2

Percentiles of the Capital Adequacy Ratio associated with losses in loans to non-financial firms, 10,000 replications. The Capital Adequacy Ratio observed in 2005 was 11.3 percent.

		2006	2007	2008
Baseline	p0.5	10.6	10.7	10.8
	p1	10.8	10.8	10.9
	average	11.3	11.4	11.4
	p50	11.4	11.4	11.4
Disruptive adjustment	p0.5	10.5	10.3	10.1
	p1	10.6	10.5	10.2
	average	11.2	11.1	10.9
	p50	11.2	11.1	11.0
Cyclical asynchrony	p0.5	10.5	10.2	9.9
	p1	10.6	10.4	10.0
	average	11.2	11.1	10.8
	p50	11.3	11.1	10.9

The figures for the cyclical asynchrony case are similar and should pose no difficulties. For instance, the CAR does not fall below 9.9 percent with 99.5 percent probability in 2008, and the expected CAR in that year is 10.8 percent.

The general conclusion is that the impact of risk associated with the non-financial firms' credit portfolio on the CAR under the stress scenarios is well within the bounds recommended in the Basel II Accord.

Box 2 – Evaluating interactions between real and financial variables in Portugal

As a complement to the stress tests, a study on the empirical interactions between real and financial variables in the Portuguese economy was also undertaken, resorting to a set of identified shocks using a vector autoregressive (VAR) approach. The study followed a two-step procedure.

In the first step, the response of several macroeconomic variables – real and financial - to monetary policy and technology shocks was characterised. Here, it was concluded that the Portuguese economy responds to these shocks in line with the stylised findings reported in the literature for the main advanced economies[19]. In particular, the financial

19 A full set of results can be found in N. Alves (2006). The paper is available upon request.

variables under study – the annual flow of non-performing loans (NPLs) as a fraction of total loans, NPLs as a fraction of total loans, real credit to households, real credit to firms, real house prices and real stock prices - respond significantly and in line with theory to the two identified shocks.

In a second step, the feedback effects from financial shocks to the macroeconomy were uncovered. To this end, shocks to standard measures of the financial stance were identified and their impact on a set of macroeconomic variables was assessed. The analysis concluded that real macroeconomic variables respond sizeably and significantly to the identified financial shocks. Therefore, there seems to be a sizeable link from the financial to the real side of the economy.

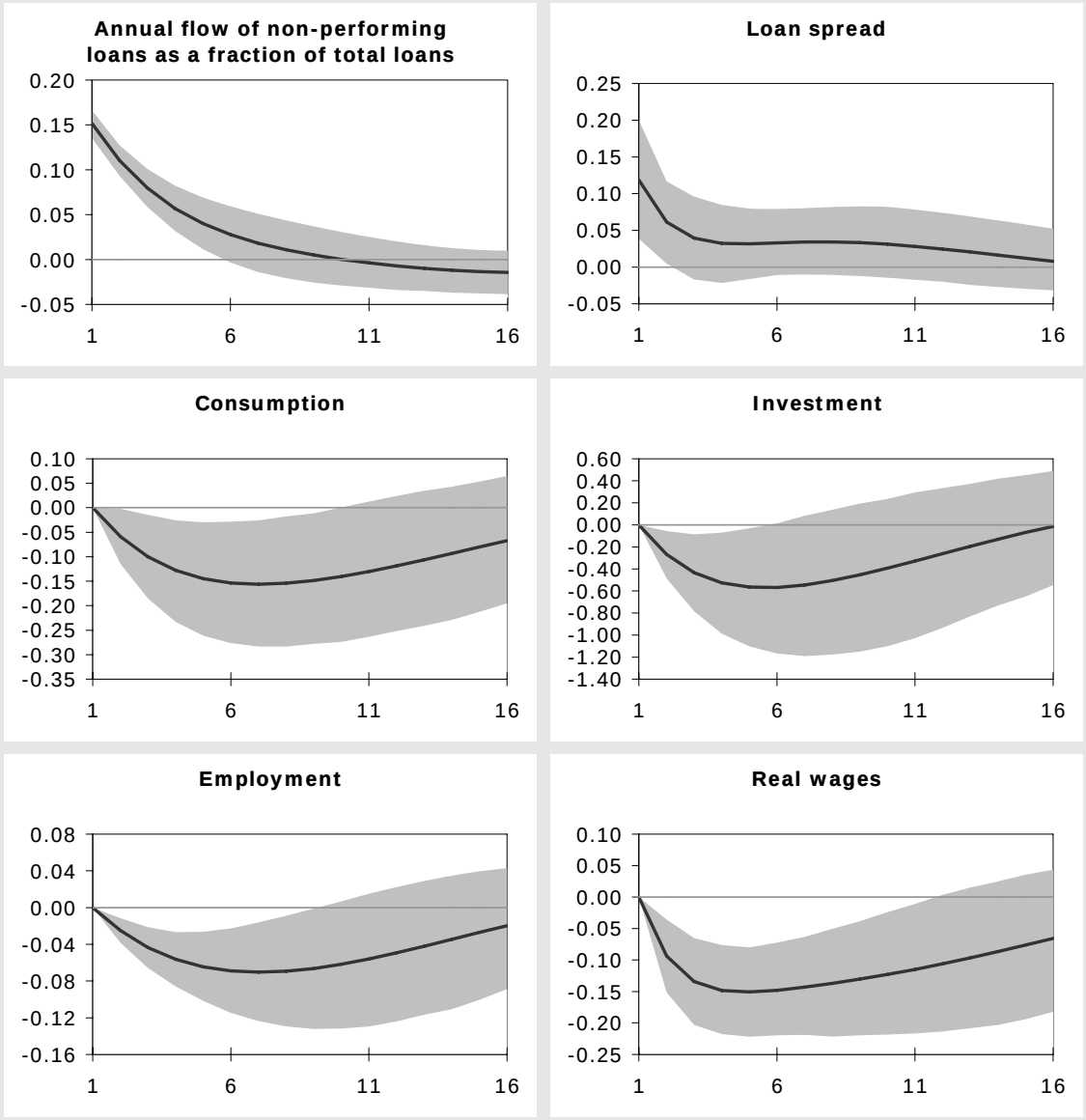
This second step may be illustrated by presenting the results concerning the impulse responses to a shock to the ratio of the annual flow of NPLs to total loans. These "NPL shocks" were estimated within a 7-variable VAR, with consumption per capita, investment per capita, real wage per worker, employment, GDP deflator, the ratio of the annual flow of NPLs to total loans, and a loan spread[20]. Given the interest in analysing the interaction between real and financial variables, the sample period was restricted to 1990Q1-2004Q4. All VARs were estimated with one lag. This was consistently found to be the optimal number of lags by the Schwartz criterion.

The NPL shocks were identified by assuming that they affect contemporaneously the ratio of the annual flow of NPLs to total loans and the loan spread, but have no contemporaneous effect on the remaining real and nominal variables of the VAR. This recursiveness assumption implies that any shock that affects consumption, investment, prices, employment or real wages contemporaneously cannot qualify as a NPL shock. Assessing the contemporaneous response of the loan spread to the shock is also interesting, given that one would expect these loan spreads to rise temporarily after the NPL shock.

Figure 1 represents the impulse responses of all the variables to a one standard-deviation positive NPL shock, together with the respective two standard-error bands. This shock corresponds to an increase in the annual flow of NPLs as a fraction of total loans of about 0.15 p.p. on impact. This shock is persistent, lasting for over a year. Interestingly, the loan spread rises by about 0.10 p.p., and this rise also persists for some quarters. After the shock, activity falls in a hump-shaped manner. This fall is related not only to the behaviour of consumption (which reaches a maximum of -0.15 per cent after 7 quarters) but also of investment. In turn, the labour market displays a gradual fall in both real wages and employment. These findings are supportive of the existence of a feedback role of non-performing loans to real macroeconomic activity.

20 This spread was defined as the difference between the average interest rate on loans to the non-financial private sector and a 3-month money market rate computed for the Portuguese economy.

Figure 1 – Impulse response functions to a temporary shock to NPLs



Note: Per cent deviations from steady state, except for non-performing loans and the loan spread, which are expressed in p.p. deviations. Time scale in quarters.

An important question in this context is whether these shocks help in explaining a significant fraction of the variability of the main macroeconomic variables in the sample period under study. Table 1 aims at answering this question. The table presents the percentage of the variance of the forecast error for several variables that can be attributed to the “NPL shocks”. The forecast error is evaluated for several horizons. It is clear from the table that NPL shocks explain only a very minor portion of the real and nominal variability found in the data. This finding suggests that the significant decline observed in NPLs in the second half of the 90s was related to the evolution of other macroeconomic variables - of which the decline in interest rates and the boom in activity may have been dominant - rather than being related to exogenous developments.

Table 1

Variance decomposition: percentage attributed to shocks to the annual flow of NPL as a fraction of total loans

Quarters	Consumption	Investment	Employment	Real wages	GDP deflator
4	0.5	1.7	0.3	1	4
8	0.4	3	1.8	0.9	4.6
12	0.7	3.7	3.3	0.8	4.3
16	1	4	4.1	0.9	3.9

The main conclusions of this analysis are therefore twofold: on the one hand, there is evidence that shocks to non-performing loans have a significant impact on real macroeconomic variables in the Portuguese economy; on the other, these shocks played a negligible role in explaining the dynamics of the data in the sample period under study. Here, it must be stressed that the main role of the financial side of the economy may not lie on the importance of exogenous shocks hitting this sector but rather on its importance in magnifying/dampening the propagation of the myriad of other shocks hitting the economy - for example through an accelerator mechanism as commonly described in the literature.

As a final note, it should be highlighted that the VAR analysis presented in this box shares all the caveats usually attributed to this type of methodology. In particular, the issue of determining whether the uncovered shocks really correspond to those one aims to identify is most relevant in this context.

References

Alves, N. (2006), “Dynamic interactions between real and financial variables in Portugal”, Banco de Portugal, mimeo.

Antunes, A., Ribeiro, N. e Antão, P. (2006) “Estimating probabilities of default under macroeconomic scenarios”, Financial Stability Report, Banco de Portugal

Dwyer, D. (2005) “Examples of overfitting encountered when building private firm default prediction models”, New York, Moody’s KMV

IMF (2005), Financial Sector Assessment – A Handbook, September

Virolainen, K. (2004) “Macro stress testing with a macroeconomic credit risk model for Finland”, Working paper 18/2004, Bank of Finland

OCCASIONAL PAPERS

2007