

THE DISTRIBUTION OF LOSSES IN CREDIT TO NON-FINANCIAL FIRMS*

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1. INTRODUCTION

The aim of this article is to characterise the distribution of losses in loans to Portuguese non-financial firms under different macroeconomic scenarios. The topic is relevant for several reasons. First, periodic assessments by international agencies aimed at evaluating the soundness of a country's financial system require the setup of credit default models for loans in several market segments, along with other sophisticated tools for economic analysis. For instance, in 2006 the IMF conducted a Financial Sector Assessment Programme (FSAP) in Portugal. In this context, a credit default model incorporating macroeconomic factors was developed at Banco de Portugal. The model was used to estimate both the expected loss and the distribution of losses in loans to non-financial firms, which are obvious measures of interest for the assessment.¹ Second, from a banking supervision perspective, it is useful to gauge the impact of adverse macroeconomic shocks on the banking system in terms of the Capital Adequacy Ratio (CAR). For instance, one might be interested in assessing how much capital a particular set of banks (or a single bank) would need to cover low-probability unexpected losses, under a given adverse macroeconomic scenario. As credit losses are obvious and important drivers of banks' profitability, regulators dedicate a significant share of their efforts in ensuring that both expected and unexpected credit losses in a given horizon under stressful scenarios are adequately covered by either provisions or own funds, or a combination of both. Third, periodic assessments of credit risk might use the distribution of losses to identify significant vulnerabilities of the loan portfolio to non-financial firms. For instance, suppose an analyst considers two different macroeconomic scenarios: one with particularly high interest rates, the other with a particularly large upsurge of unemployment. If the analyst concludes that under the first scenario the distribution of losses is somewhat more adverse than under the second scenario, this might lead her to recommend a careful focus of the assessment on interest rate-related issues.

Based on credit register and other data on Portuguese firms, we use a binary response model to estimate the probability of default on a loan by a firm. We perform Monte Carlo simulations to estimate the distribution of losses in loans to Portuguese non-financial firms under a "baseline" macroeconomic scenario and two "stress" scenarios, labelled "disruptive adjustment" and "cyclical asynchrony".² The macroeconomic scenarios span the period 2005-2008 and consist of complete and consistent projections for the Portuguese economy using a full-fledged macroeconomic model.³ All scenarios were constructed using information available by December 2005. Thus, the macroeconomic scenarios presented here are not forecasts of current macroeconomic conditions, nor do they reflect Banco de Portugal's assessment of

* The analyses, opinions and findings of this paper represent the views of the authors, they are not necessarily those of the Banco de Portugal.

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(1) Banco de Portugal (2007) *Occasional Paper no.1*, presents the design and results of the stress tests carried out in the context of the 2006 IMF FSAP; parts of that paper overlap this article.

(2) Details about the statistical model and other aspects of the default probability estimation are provided in Antunes, Ribeiro and Antão (2005).

(3) Details about the macroeconomic model used in the projections can be found in Castro (2005).

what a stressful macroeconomic scenario would be under the current conditions. Rather, these results aim merely at giving a broad perspective about what an assessment of aggregate credit risk might look like at a particular point in time.

The “baseline” scenario is an extension to 2008 of the macroeconomic projections conducted in the context of the Eurosystem December 2005 Broad Macroeconomic Projection Exercise.⁴ It comprises a moderate recovery of overall macroeconomic conditions during the 2006-2008 period.

The “disruptive adjustment” scenario assumes an abrupt adjustment of the global imbalances in 2006. US economic activity sharply decelerates, and worldwide economic activity ensues. There is a real appreciation of the euro with respect to the dollar and a sharp decline in global stock prices. The ECB is assumed to adjust its monetary policy by cutting intervention rates.

The “cyclical asynchrony” scenario considers the impact of an unexpected increase in productivity in the euro area, causing higher domestic demand and imports. This, however, does not spill over to Portuguese exports. Oil prices increase throughout the simulation horizon. The ECB adjusts short-term interest rates upwards. Cyclical asynchrony between Portugal and the euro area economy reflects falling economic activity in Portugal while the rest of the euro area grows briskly.

The macroeconomic scenarios are fed into the credit default model. Under simplifying assumptions and using Monte Carlo simulations, we are able to study the distribution of losses in loans to non-financial firms, as well as changes on the Capital Adequacy Ratio (CAR) of the Portuguese banking sector associated with each scenario.

We conclude that the distribution of losses is right-skewed, with percentile 95 of the loss in 2008 equal to 184 per cent of the mean in the baseline scenario and 146 per cent in the disruptive adjustment scenario; the figure for the cyclical asynchrony scenario is 144 per cent. These results imply that, as expected losses increase, losses tend to lie nearer to the mean in relative terms. In other words, under “baseline” conditions, expected losses in 2008 are low and there is a 5 per cent chance that losses are more than 84 per cent higher than the average; under “stress” conditions, expected losses are high, but with the same probability of 5 per cent, losses will be just 44 or 46 per cent higher than the average. There seems thus to exist a mechanism that narrows the distribution of losses as expected losses increase.

In terms of the overall CAR, we conclude that the Portuguese banking sector was, as of end-2005, perfectly capable of absorbing the large macroeconomic shocks posited in the stress scenarios, with the CAR ratio well-above the minimum requirement of 8 per cent in the entire simulation period. Given actual data for 2005, our estimates imply that yearly losses on the corporate portfolio are comfortably below the regulatory capital buffer with probability of 99.5 per cent.

This article is organised as follows. The [next section](#) briefly describes the macroeconomic scenarios, the data, the model for defaulted loans, and the procedure adopted in the estimation of losses. [Section 3](#) then presents the main features of the loss distribution. [Section 4](#) assesses the impact of macroeconomic conditions on the CAR of the entire Portuguese banking system, holding all other risk factors constant. [Section 5](#) concludes.

(4) These projections were superseded by Banco de Portugal's forecasts published in summer 2006 and winter 2006 issues of *Economic Bulletin*.

2. MODELLING LOSSES UNDER MACROECONOMIC SCENARIOS

This Section describes the macroeconomic scenarios, the data and the model for defaulted loans, the procedure adopted in the estimation of losses, and is mostly a summary of material available in Antunes, Ribeiro and Antão (2005).

2.1. The macroeconomic scenarios

We use a “baseline” and two “stress” macroeconomic scenarios. They consist of complete and integrated projections of macroeconomic conditions for the Portuguese economy using a full-fledged macroeconomic annual model.⁵

The baseline scenario is an extension to 2008 (with small changes) of the macroeconomic projections conducted in the context of the Eurosystem December 2005 Broad Macroeconomic Projection Exercise. It comprises a moderate recovery of macroeconomic conditions during the 2006-2008 period *vis-à-vis* 2005.

The disruptive adjustment scenario posits an abrupt adjustment of the global imbalances in early 2006. There is a sharp deceleration of the US economic activity, which translates into a slowdown in worldwide economic activity. Investors’ portfolios shy away from the US dollar, leading to a real appreciation of the euro *vis-à-vis* the dollar. There is also 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.

As in the disruptive adjustment scenario, the cyclical asynchrony scenario considers the impact of an unexpected increase in productivity in the euro area. The cyclical asynchrony scenario includes negative output growth over the simulation horizon. However, the recession observed in this scenario is milder than that of the disruptive adjustment scenario. Gross fixed capital formation and private consumption are most affected by interest rates’ surge. The increased external demand does not cause a rise of Portuguese exports; instead, a 3 per cent market share loss in each year is assumed *vis-à-vis* the baseline. This scenario thus involves negative GDP growth and high interest rates and inflation.

Table 1 provides details about the scenarios in terms of the short-term interest rate and the GDP growth rate.

2.2. The data and the statistical model

The data come from two sources: the credit data from the *Central de Responsabilidades de Crédito* (CRC), which is the Portuguese credit register; and the *Estatísticas Gerais* (EG) database for firm-specific information. We used a sample of firms 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), which was stratified by activity sector (in a total of 15 different activity sectors). We defined the “loan” as the statistical unit of observation, since this is the relevant concept of interest when looking at default events in particular loans. A “loan” is understood to be the bilateral credit relationship between a firm in the sample and a single financial intermediary. The CRC monthly data were transformed into quarterly data. The sample includes almost 2 million observations and ranges from 1995q1 to 2004q4.

(5) As mentioned above, the macroeconomic scenarios should be interpreted as merely illustrative. See footnote 4.

Table 1

MACROECONOMIC SCENARIOS				
Values in percentage				
	2005	2006	2007	2008
Baseline				
Short-run interest rate	2.2	2.2	2.3	2.4
GDP growth rate	0.3	0.8	1.0	1.3
Disruptive adjustment				
Short-run interest rate	2.2	1.0	0.8	0.9
GDP growth rate	0.3	-1.0	-0.7	-0.1
Cyclical asynchrony				
Short-run interest rate	2.2	3.6	4.2	4.9
GDP growth rate	0.3	-0.2	-0.6	-0.2

We use a *probit* model with the “default event” defined as follows. For any given loan, we first compute its total amount and the past due amount (which is equal to or less than the previous quantity). The “default” occurs when positive past due amounts are registered in three consecutive months and the amount past due three months ago was zero.

The model includes regressors at the loan, firm and aggregate levels. Examples include, at the loan level, 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. At the firm level, we use, for instance, categorical variables for the activity sector and the firm’s total debt. At the macroeconomic level, we use, for example, short-term nominal interest rates and deviations of GDP from trend.

We determine the distribution of losses through Monte Carlo simulations. In each simulation, we use the model to randomly classify each loan as having defaulted or not. Summing all “defaulted” loans, we have an aggregate measure of loan defaults for that particular experiment. Repeating this procedure many times allows us to obtain a Monte Carlo estimate of the loan loss distribution.

In order to perform the simulations under the three macroeconomic scenarios, we assume that the characteristics of the credit portfolio do not change in response to macroeconomic conditions. Therefore, all the variation in the loss distribution is caused by changes in the macroeconomic variables, either directly or through their interactions with firm-level variables. This hypothesis may be subject to criticism, since it ignores the endogenous portfolio change that would occur as the macroeconomic conditions evolved, firms defaulted and eventually exited activity, and new firms and loans arrived. We chose to keep the portfolio unchanged, implicitly assuming that the firms and loans leaving the portfolio do not differ significantly from entrant firms and loans.

A number of criticisms may be cast over this exercise. The credit default model just described omits important dimensions that might help explain default. This was a consequence of the lack of comprehensive data on the firms’ balance sheets. The use of more comprehensive information would allow for a better characterisation of each firm. Some econometric issues might also be raised (such as non-observed heterogeneity); other working hypotheses, in particular those assuming a fixed portfolio structure, may also be insufficient or inadequate. In view of these criticisms, the results should be interpreted cautiously.

Due to computational constraints, we used a sample covering the entire portfolio of credit to Portuguese non-financial firms as of end-2004. We performed 10,000 experiments for each year and scenario in the simulation horizon.

3. THE DISTRIBUTION OF LOSSES

Before we turn to the distribution of losses, let us first take a look at their expected values. Table 2 presents expected losses in yearly terms for the scenarios as a percentage of total exposure to non-financial firms, where it was assumed that on average 50 per cent of a defaulted loan is effectively lost.

As expected, the stress scenarios have in 2008 more than twice the expected loss of the baseline scenario. This is mostly due to the economic recession embedded in both the disruptive adjustment and the cyclical asynchrony scenarios. The cyclical asynchrony scenario induces the highest loss as of 2008 due to the high interest rates. As for the disruptive adjustment scenario, lower interest rates (relative to the baseline) are not enough to compensate for the strong and negative economic growth effect. In both cases, GDP grows considerably below its long-run trend.

Charts 1 and 2 present the distribution of losses as a fraction of the mean loss in the baseline and each stress scenario.⁶ Table 3 presents percentiles of the loss measured as a percentage of mean loss, for the three scenarios.

Consistent with the fact that, in the baseline scenario, macroeconomic variation is such that the expected loss decreases very slowly in the simulation horizon, the distribution of losses shows little variation. In general terms, total losses are skewed to the right, with the median at around 90 per cent of the average in the whole simulation horizon. The distribution is also bimodal, a characteristic common to the stress scenarios up to 2006. For instance, in 2005 there is a local maximum of the probability density just above 160 per cent of the mean for the baseline case. This probably has to do with the concentration of large loans in the credit portfolio. For relatively benign outcomes, only some large loans default and we have losses around the median. However, if a sufficient number of large loans defaults, the cumulative effect is going to be that at some large value the density of probability becomes considerable. This might happen 10 per cent of the time, which is approximately the probability mass above 1.5 in Chart 1 for 2005.

As documented in Table 3, the characteristics of the relative loss distribution under the disruptive adjustment scenario do not differ much from the baseline. At a first glance, the most striking difference between both is the fact that the secondary hump is closer to the mean by the end of the projection horizon. There is some preliminary evidence that this hump is partly associated to portfolio concentration in large firms, which suggests that adverse shocks feed through the credit loss distribution mostly by increasing the expected value of default probabilities in the portfolio of smaller firms, while the unexpected part arises essentially from larger firms. This is in line with the rationale for calibrating the Basel II risk weighted assets

Table 2

ESTIMATED YEARLY LOSSES IN EACH SCENARIO FOR CREDIT PORTFOLIO TO NON FINANCIAL FIRMS				
All values in percentage				
	2005	2006	2007	2008
Baseline	1.1	1.1	1.0	1.0
Disruptive adjustment	1.1	1.5	1.7	2.1
Cyclical asynchrony	1.1	1.4	1.8	2.3

(6) All histograms in this article are kernel density estimates using the artificially generated data.

Chart 1

DISTRIBUTION OF YEARLY LOSS AS A FRACTION OF THE MEAN
Baseline and disruptive adjustment scenarios

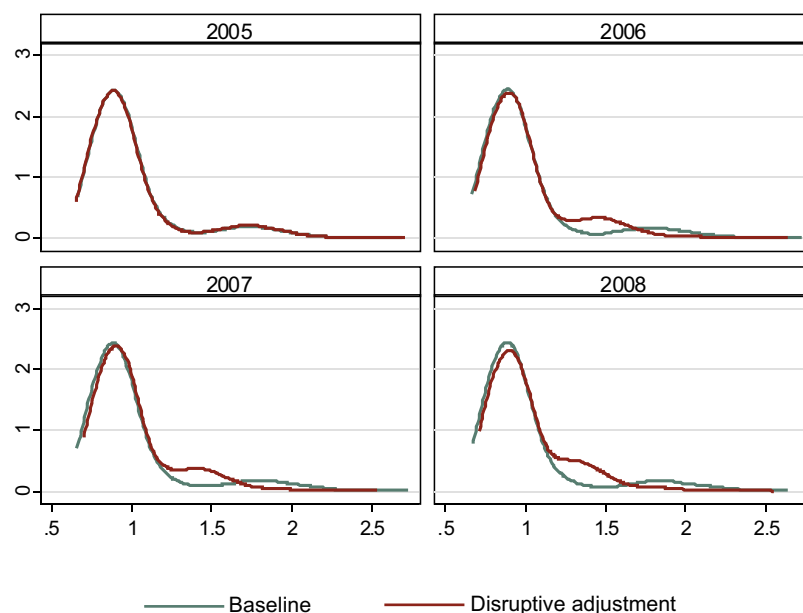


Chart 2

DISTRIBUTION OF YEARLY LOSS AS A FRACTION OF THE MEAN
Baseline and cyclical asynchrony scenarios

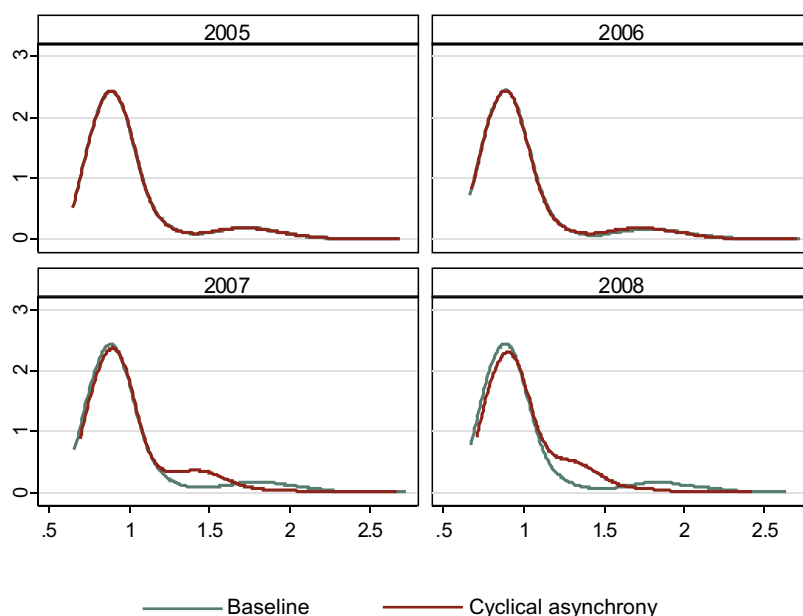


Table 3

PERCENTILES OF THE YEARLY LOSS AS A PERCENTAGE OF THE MEAN		2005	2006	2007	2008
Baseline	p1	73	73	72	73
	p5	77	77	76	76
	p50	90	90	89	90
	p95	177	181	183	184
	p99	208	217	218	221
Disruptive adjustment	p1	73	75	75	76
	p5	77	78	79	79
	p50	90	91	92	91
	p95	177	156	152	146
	p99	208	188	185	183
Cyclical asynchrony	p1	73	73	75	76
	p5	77	77	78	79
	p50	90	90	91	92
	p95	177	178	153	144
	p99	208	209	193	177

formulae, whose parameters are, *ceteris paribus*, more favourable to corporate and retail SMEs, than large corporations.

Under the disruptive adjustment scenario, the coefficient of variation (defined as the ratio of the standard deviation to the mean) of the loss distribution decreases by 32 per cent during the simulation horizon. This decrease in the relative dispersion of losses is consistent with the framework put forward in Basel Committee on Banking Supervision (1999). There it is shown that the coefficient of variation of a particular facility is roughly proportional to $\sqrt{1/p}$ for small p , where p is the probability of default.⁷ Since under the disruptive adjustment scenario p deteriorates uniformly across facilities, the coefficient of variation of the total credit loss distribution should also decrease.

The above comments also apply to the cyclical asynchrony scenario. There is essentially one difference between the two stress scenarios. By the end of the simulation horizon, expected losses are higher for the cyclical asynchrony case, which is a consequence of the higher interest rates.

The amount of losses relative to total exposure that is lost cannot be conveyed by Charts 1 and 2. In terms of the relevant exposure, we see from Table 2 that, in yearly terms, about 1 per cent of total exposure is lost in the baseline case. Charts 3 and 4 and Table 4 characterise the yearly total loss as a percentage of the total exposure amount. This is a relative Value-at-Risk (VaR) measure. For instance, the 99 per cent VaR is the threshold above which losses lie 1 per cent of the years.⁸

Let us now turn to the relative VaR results. The most prominent difference between the baseline and the stress scenarios is that the distribution in the stress scenarios shifts to the right during the simulation period (Charts 3 and 4), while that of the baseline scenario remains roughly static. This reflects the adverse macroeconomic environment embedded in the stress scenarios.

(7) This is true whether Loss-Given-Default is stochastic or not.

(8) This study considers only the VaR of loans to non financial firms. It should be noted that the VaR of loans to non financial firms does not add up with the VaR of loans, for instance, to households.

Chart 3

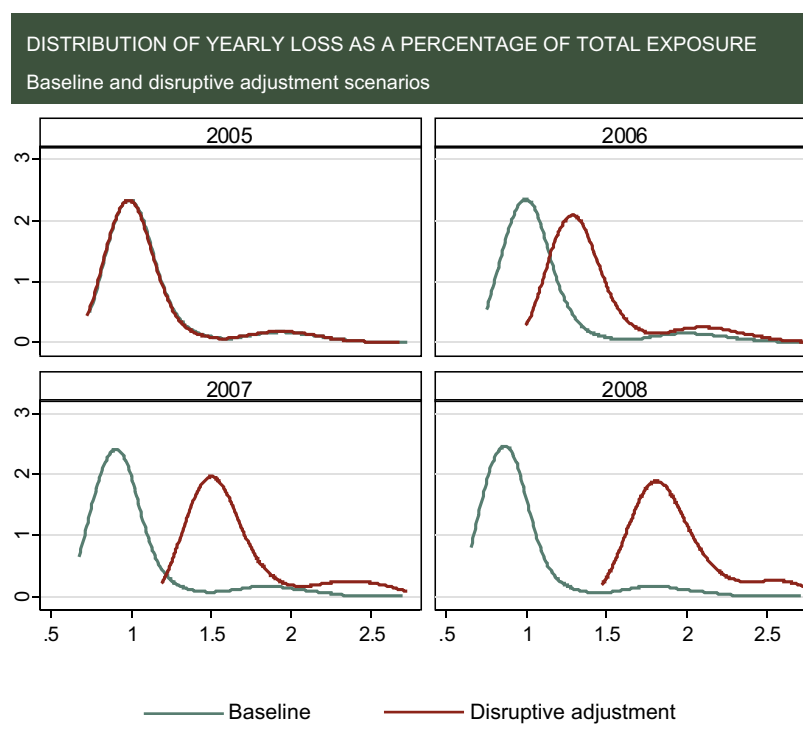


Chart 4

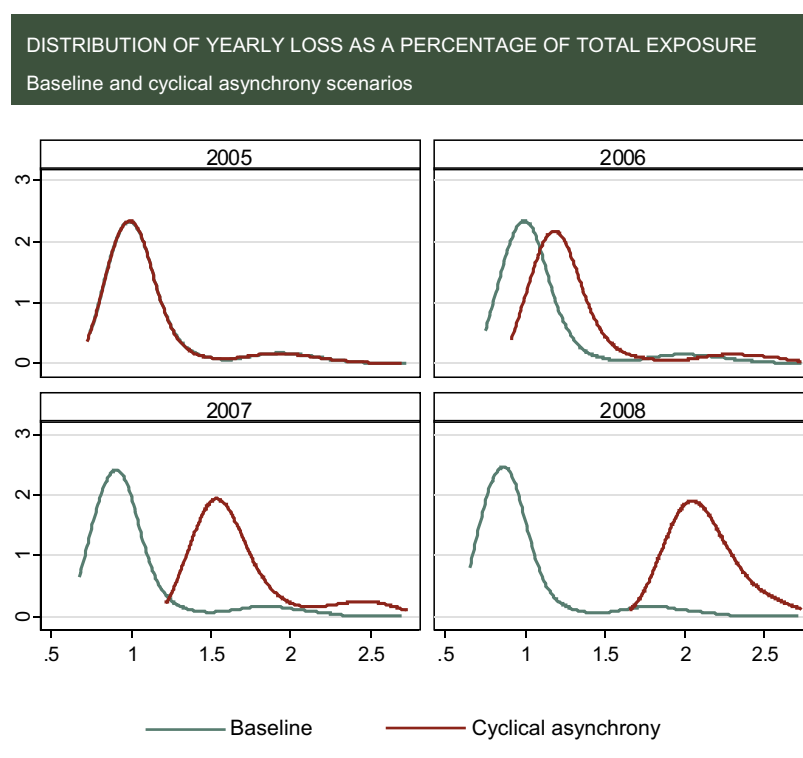


Table 4

PERCENTILES OF THE YEARLY LOSS AS A PERCENTAGE OF TOTAL EXPOSURE					
		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

We see in Table 4 that the baseline scenario total loss in 2005 is estimated to be less than 2 per cent of the aggregate exposure with a 95 per cent probability. If we want to be more conservative, these results suggest that at most 2.3 per cent of the exposure is lost in 2005 with a 99 percent confidence level.⁹ We see that the decrease of losses in the simulation horizon is accompanied by a decrease in the 95 and 99 percent levels. For the disruptive adjustment scenario, the corresponding values increase by 1 and 1.5 percentage points. These figures are, respectively, 1.4 and 1.8 for the cyclical asynchrony case. This implies that, in terms of credit to non-financial firms, the cyclical asynchrony scenario is more stringent than the disruptive adjustment scenario, both on average and on the right tail of the loss distribution.

To convey a quantitative notion of how much outcomes differ under the baseline and the stress scenarios, let us give an example. For the disruptive adjustment scenario, the median loss in 2008 is 1.9 per cent of total exposure. In contrast, such loss corresponds to the percentile 96 in the baseline case. Therefore, if the disruptive adjustment scenario materialised, an outcome with loss above 1.9 per cent of exposure would be likely (50 per cent probability), while under the baseline scenario, such an adverse outcome would still be possible, but much less likely (4 per cent probability).

4. IMPACT ON THE CAPITAL ADEQUACY RATIO (CAR)

This section deals with the way losses affect the Capital Adequacy Ratio (CAR) under the three macroeconomic scenarios.¹⁰ To this aim, we make simplifying assumptions about the behaviour of banks throughout the simulation horizon. We assume that losses follow the distribution documented in section 3. We use own funds, risk-weighted exposure and total exposure as of end-2005, and proceed to the estimation of the changes in own funds due to loss variability. We then use these estimates in order to obtain the impact of losses in credit to non-financial firms on the CAR, abstracting from any other impact. We thus make the simplifying assumption that variability of losses in credit to non-financial firms is the sole source of variability during simulations.

(9) 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 per cent.

(10) The Capital Adequacy Ratio (CAR) is the quotient between consolidated own funds and risk-weighted exposure.

The starting point for the CAR was calibrated with actual data, i.e. the average aggregate figure for the whole banking system at end-2005 (11.3 per cent). This level implied a capital buffer of around 3.3 points, which results from the comparison with the 8 per cent minimum regulatory level. It should be pointed out that this minimum level of capitalisation could be understood under a Basel II framework as the one which is sufficient to cover extreme unexpected losses in a one year horizon, after taking into account the provisioning adequacy covering expected losses, and assuming that sound risk management system controls are in place. In other words, 8 per cent of the risk weighted exposure would be the Value-at-Risk at some conservatively high confidence level, for instance 99.5 per cent. Accordingly, the probability of losses in excess of own funds requirements over a one-year horizon would be lower than 0.5 per cent.

The exercise that we are going to perform is the following: what is the distribution of the capital buffer (the excess capital over the minimum) given that (i) the overall characteristics of the credit portfolio to non-financial firms remain unchanged; (ii) expected own funds, risk-weighted exposure and total exposure remain at their 2005 levels; (iii) all other sources of risk are either ignored or assumed to be covered by provisions or the expected flow of income; and (iv) the macroeconomic environment is changing according to a given scenario?

Since losses impact own capital directly and we assume that supervisory capital and risk-weighted exposure are kept at their 2005 levels, the capital buffer distribution in percentage points of the CAR is similar to those of Charts 1 and 2, appropriately inverted and rescaled. This is of course a simplifying assumption. When faced with macro-economic surprises impacting on credit losses, banks adjust their portfolio (towards or away from, and within, credit to non-financial firms). As defaults occur and new firms start activity, the characteristics of the pool of risks also changes. We thus assume that banks change their portfolio and allocate supervisory capital so as to keep expected risk-weighted exposure and own funds requirements at their 2005 levels.

Table 5 presents the results. The probability that, in 2008, the capital buffer would be lower than 2.8 percentage points is 0.5 per cent in the baseline. In the disruptive adjustment scenario, the corresponding figure at the end of the simulation horizon is 2.1 percentage points. For the cyclical asynchrony case, the value is 1.9 percentage points. This means that the portfolio of credit to non-fi-

Table 5

PERCENTILES AND AVERAGE OF THE CAPITAL BUFFER RESULTING FROM LOSSES IN CREDIT TO NON-FINANCIAL FIRMS

All values in percentage points

		2006	2007	2008
Baseline	p0.5	2.6	2.7	2.8
	p1	2.8	2.8	2.9
	average	3.3	3.4	3.4
	p50	3.4	3.4	3.4
Disruptive adjustment	p0.5	2.5	2.3	2.1
	p1	2.6	2.5	2.2
	average	3.2	3.1	2.9
	p50	3.2	3.1	3.0
Cyclical asynchrony	p0.5	2.5	2.2	1.9
	p1	2.6	2.4	2.0
	average	3.2	3.1	2.8
	p50	3.3	3.1	2.9

nancial corporations would be responsible for, at most, the erosion of roughly one third of excess capital in a three-year horizon with 99.5 per cent probability and conditional on the materialisation of particularly stressful macroeconomic scenarios.

The main conclusion from this exercise is that the impact of purely macroeconomic factors on the CAR via non-financial firms, though significant, appears manageable, even under very extreme and conservative assumptions.

5. FINAL REMARKS

This article describes and presents results concerning the distribution of losses in the credit portfolio to Portuguese non-financial firms under three different macroeconomic scenarios (the baseline, the disruptive adjustment and the cyclical asynchrony scenarios), for Portuguese banks as a whole. The main conclusions are: (i) macroeconomic factors affect the distribution of losses both in terms of location (mean, median) and shape (skewness, dispersion and relative placement of modes); (ii) the stress scenarios induce a behaviour of losses that is much more adverse than under the baseline scenario; (iii) the cyclical asynchrony scenario is more stressful than the disruptive adjustment scenario due essentially to higher interest rates; (iv) even though other risk sources were ignored in the analysis and should be taken into account to deliver a more complete picture, the capital buffer of the banking system as a whole looks adequate to absorb swiftly very unlikely credit events in the corporate portfolio, leaving the capital adequacy ratio comfortably above the minimum regulatory level.

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