

Stress testing banks' profitability: evidence from France¹

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Abstract

In this paper, we propose a stress testing framework to evaluate the sensitivity of the banking system's profitability to plausible but severe adverse macroeconomic shocks. As empirical evidence, we test the resilience of French bank's profitability using supervisory data over the period 1993-2008. First, we prove that French banks' profitability depends significantly on

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macroeconomic and financial variables (GDP growth, interest rate spread, stock market's volatility) and bank-specific variables (size, capital ratio, ratio of non interest income to assets). Second, our original macroeconomic stress testing exercises show that French banks' profitability is resilient to major adverse macroeconomic scenarios.

JEL classification: C23; G21; L2.

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1. Introduction

During the last decades, the banking systems of developed countries experienced a major makeover as to their sources of revenue, the traditional net interest revenue being increasingly associated with fees & commissions and trading incomes. According to some observers, this development could go hand-in-hand with weaker resilience of banks' revenues to adverse shocks. Yet, several banking systems, among which the French one, went through the current financial crisis without any failure and their profitability remained strong in spite of a strong economic and financial downturn. As a matter of fact, the French banking system proved profitable even through 2008 and 2009.

From the supervisory point of view that aims at ensuring the banking system's solvency, identifying the vulnerabilities of banks' profitability is crucial. *First*, profits prove to be a, if not the main, driver of bank capital (Gropp and Heider, 2009). Hence, any trouble regarding bank's profitability is likely to pass on to solvency position, in the end threatening the banking system's strength. *Second*, in line with the "bank capital channel" literature (van den Heuvel, 2002), banks facing a slump in profits, together with difficulties to issue additional equities, are likely to ration credit in order to meet regulatory constraints, and finally to slow down the business cycle. *Third*, profits are known to be reliable early-warning indicators of financial distress (Demirgüç-Kunt and Detragiache, 1999), though they are available at a, at best, quarterly frequency. This low profitability data frequency, plus their backward-looking nature, makes it fundamental for regulators to identify the main determinants of profits in order to run accurate forecasts and make out vulnerabilities in a more forward-looking manner.

The early research dedicated to banks' earnings sources focuses on net interest margins (Flannery, 1981; Ho and Saunders, 1981). In that respect, Allen (1988), Saunders and Schumacher (2000), and Demirgürc-Kunt and Huizinga (2000) highlight a robust relationship between interest margins and the business cycle.

Nevertheless, the growing importance of non-interest income (fees & commissions and trading incomes) progressively lessens the importance of net interest incomes. Aggregate measures of profitability gain a special importance over the recent years, among which Return-on-Equity (ROE) and Return-on-Assets (ROA). Three types of determinants are generally found significant: *firm-specific* variables (the amount of capital, the ratio of expenditures, the size of the bank proxied by its total assets, and the risk born by the financial institution) as stated by Goddard *et al.* (2004), Kosmidou *et al.* (2006), Athanasoglou *et al.* (2008), and Albertazzi and Gambacorta (2009); variables linked to the *market's structure* (the market power of the bank, the share of non-interest income), as established by Smirlock (1985), Berger (1995), Lepetit *et al.* (2008); and finally *macroeconomic and financial* variables (GDP growth, interest rate spread, inflation, stock market's return and volatility, loan growth), as established, among others, by Revell (1979), Molyneux and Thornton (1992), Demirguc-Kunt and Huizinga (2000), Beckmann (2007), Athanasoglou *et al.* (2008), and Albertazzi and Gambacorta (2009).

In order to assess the resilience of financial institutions to macroeconomic and financial shocks, supervisors and central banks have developed numerous macroeconomic stress testing methodologies over recent years. Contrary to those implemented by banks themselves, they are focused on the resilience of the financial system as a whole. Jones *et al.* (2004), Sorge (2004) and Foglia (2009), among others, provide extensive literature reviews on those practices. The purpose

of such methodologies is to test the capability of the financial system to survive severe but plausible scenarios. Hence, they appear particularly relevant tools for assessing the effects of adverse scenarios on banks' profitability in that they prove forward-looking and adapted to various unfavorable hypothetical scenarios.

In the present paper, we propose a framework to evaluate the resilience of banks revenues to adverse macroeconomic shocks, and apply it to French supervisory data. For this purpose, we first propose to identify the main determinants of French banks profitability – measured by their Return-on-Assets – both from a macro-financial point of view and from a bank-specific perspective. Second, we develop an original stress testing framework to evaluate the resistance of French banks' Return-on-Assets to adverse macroeconomic shocks.

Our contribution to the existing literature is twofold: first, we build up an original and comprehensive (i.e. not restricted to sensitivity analysis) macro-econometric stress testing framework that allows us to test for the resilience of banking profitability in the current downturn context. Second, despite Goyeau *et al.* (1998) and Goyeau *et al.* (2002) adapt the model of Flannery (1981) to *French banks'* profitability, we do not know any recent study that studies the determinants of French banks' profits, and especially as far as aggregate measures are concerned, on the basis of individual data.

Our results tend to show: first, that banks' profitability depends significantly on macroeconomic and financial variables (GDP growth, interest rate spread, stock market's volatility) and bank-specific variables (size, capital ratio, ratio of non interest income to assets); second, that French banks' profitability is resilient to major adverse macroeconomic scenarios. Those outcomes are

likely to give quantitative grounds to the fact that, at the current juncture, one did not observe any disastrous loss among the French banking system.

The remainder of the paper is structured as follows: section 2 elaborates on the data and the estimated model; section 3 presents the main results including robustness checks; section 4 describes the macro-econometric stress testing framework and the subsequent results; section 5 concludes.

2. Data and empirical model

2.1 Data

In this paper, bank-specific variables come from an original dataset made up of a panel of individual French banks' consolidated data, on a relatively long period (1993-2008) on an annual basis. Those data, called 'BAFi' which stands for 'Base des Agents Financiers' (Basis of financial agents), belong to the French banking supervisor ('Secrétariat général de la Commission bancaire').

The panel is unbalanced, that is to say, some banks may appear or disappear from time to time, essentially because of mergers and acquisitions.

Hence, we finally get an overall number of 364 different groups over the whole sample, about 170 on average each year.

2.2 Dependent variable

Our dependent variable is banks' profits. We have at our disposal three possible measures of profitability: Return-on-Assets (ROA), defined as the ratio of the net income after taxes to total assets; Return-on-equity (ROE), defined as the ratio of the net income after taxes to total equity; Net Interest Margin (NIM), defined as the ratio of the net interest income after taxes to total assets.

As the NIM is focused on transformation revenue of banks activities, whose importance in terms of share of profits progressively decreased over the recent years (Coffinet *et al.*, 2009) and does not constitute an aggregate measure of profitability, we decide not to consider it as a relevant endogenous variable for the purpose of that paper.

As regards ROE and ROA, the latter seems more adapted to supervisory issues than the former: first, it is directly related to the quality of loans, contrary to ROE, which takes on the shareholder's perspective; second, ROA may be computed as the ratio of ROE to leverage, and thus integrates the latter explicitly, which is of special interest at the current juncture. However, there might be to some extent inconsistencies between the numerator and the denominator of the ROA because the former is related to profits generated from all activities and the latter covers only the balance-sheet activities. Nevertheless, the ROA reflects the ability of banks to generate profits from all activities related to their assets. It seems particularly relevant for banks with noteworthy intermediation activities, and especially most French banks. Hence, we decide to focus on the ROA as the key ratio for evaluating banks' profitability, following the International Monetary Fund (2002) and Athanasoglou *et al.* (2008).

The Chart 1 below displays the evolution of banks' profitability during the period under consideration according to those three measures after removing outliers⁵.

[Chart 1: evolution of banks' profitability (1993-2008)]

From the outset, one notices that the overall French banking system's Return-on-Assets seems to move in accordance with the business cycle, with significant decreases in the years 1993-1994, 2001-2002 and 2007-2008, coincident with economic slowdowns or downturns. On the contrary, the periods from 1994 to 2000, and 2003 to 2006, corresponding to economic growth, exhibit an increase in the French banking system's Return-on-Assets.

Besides, the chart 1 shows that ROA and ROE behave in a very similar manner over the whole sample. The correlation between both series is found very high (93%). Hence, we can infer from that figure that results obtained on the basis of ROA figures are likely to be robust to the choice of the profitability measure (ROA vs. ROE). On the contrary, as expected, NIM is less correlated to ROA and ROE, and behaves in an opposite manner (as proved by the negative sign of the correlation coefficients). This tends to prove that the aggregate profitability of banks is on the sample rather linked to non-intermediary activities than to traditional interest revenues.

⁵ Outliers are defined as observations that are beyond the 95% percentile of profits and risk (see the following section for details) or banks in the lowest 5% percentile region.

Nonetheless, the French banking system is composed of several institutions of different legal status, that is to say commercial banks, financial and investment firms, and mutual and cooperative banks. At this stage, it might be interesting to study those three groups and compare related descriptive statistics (see Table 1).

The sample seems well-balanced between juridical forms, with, for a total of 2720 observations, 862 for commercial banks, 998 for mutual and cooperative banks and 860 for financial and investment firms. The average ROA for the whole French banking system reaches 0.67%. It is somewhat homogenous across juridical forms, as it ranges from 0.56% for commercial banks to 0.86% for financial and investment firms. As to the standard deviation, it is for financial and investment firms more than the double than that for mutual and cooperative banks, indicating a higher heterogeneity in the former group than in the latter.

[Table 1: descriptive statistics]

2.3 Explanatory variables

As regards the *bank-specific* determinants of banks' profitability, the related literature generally considers the amount of capital, the size of the bank, the risk born by the bank and the expenditures amount of the bank (Goddard et al., 2004; Kosmidou *et al.*, 2006; Athanasoglou *et al.*, 2008; Albertazzi and Gambacorta, 2009). The *amount of capital* is likely to act positively upon profitability, as capital may be interpreted as the amount of own funds available to support the bank's business, and hence as a buffer against adverse developments. This relationship may be strengthened by the M&As that occurred in the late 90s. Finally, a high capital ratio may be

viewed as a means for a bank to signal a high expected profitability. The *size* of the bank is a possible determinant of its profitability, as size can be considered as a proxy for capital adequacy since large banks raise capital at a lower cost. Nevertheless, the empirical evidence is mixed and sometimes points out a significantly *negative* relationship between size and profitability. An interpretation is that large banks could experiment negative effects due to bureaucratic reasons. The *risk born by the bank* could act in the following way: an increase in exposure to credit risk would decrease bank's profitability. The risk measure is often built as the loan-loss provision to loans ratio and is therefore only based on the credit risk, which might prove not that relevant in the context of a growing non-interest income. The relationship is generally unambiguously negative though sometimes not significant. The *expenditures* ratio of the banks (i.e. operating cost over assets) is expected to be negatively related to profitability, as improved management of those expenses may increase efficiency and raise profits. The *market power* assumption suggests that firms with large market shares and differentiated products are able to use a market power and enjoy a more secured income position. Empirical results with these approaches are quite contrasted. Another possible source of profitability is linked to the *origin of revenues*: all other things kept equal, a higher share of revenue stemming from a more profitable business is likely to act positively on the overall profit. In that respect, the increase in non-interest income could have a positive effect on banks' profitability.

All in all, we consider the following bank-specific variables:

- The 'capital' variable is defined, for each bank, as the ratio of equity to total assets;

- The ratio of non-interest income ‘nii’ is the ratio of the sum of fees and commissions, trading income and perceived dividends to total assets⁶;
- The ‘expenditures’ ratio is defined as the ratio of total expenditures to total assets;
- The size of the bank variable is built as dummy variables: ‘Large’ for banks whose balance-sheet amount is in the upper quartile and ‘Small’ for those whose balance-sheet is in lower quartile;
- The ‘risk’ is the ratio of loan loss provisions to total loans;
- The ‘market power’ variable is the individual net operating income over the total net operating income of the banking industry.

The *macroeconomic and financial determinants* reflect the economic and financial environment which can also affect banks’ performances. They are the same across banks and hence represent as many cross-sectional common factors. Six macroeconomic and financial variables are often considered: economic growth, inflation, interest rate spread (split or not between short-term and long-term rate), stock index return and volatility, and loan growth. There are several reasons why output *growth* may have a positive impact of banking profitability. First, higher growth may

⁶ Alternative measures could be the ratio of non-interest income to total income or the ratio of net non-interest income to total net operating income (DeYoung and Roland, 2001; Stiroh, 2004; Stiroh and Rumble, 2006; Lepetit *et al.*, 2008). However, those measures prove to be not robust in the outcomes of regressions, or make the other variables’ significancy less robust. Hence, we decided to rely on that ‘nii’ measure, very robust whatever the specification of the model, and already used by Smith *et al.* (2003) and DeYoung and Rice (2004).

results in a higher loans distribution (increased demand) and indirectly higher revenues coming from the markets, due to higher stock market returns. Second, provisions could decrease in economic upturns, in the context of future profits, and hence the capital may have a positive impact on profitability. Empirically, many studies find a significantly positive relationship between GDP growth and banking profitability. The effect of *inflation* on profitability is not unambiguous. The effect of inflation on profitability essentially depends whether bank's expenses grow at a faster pace than inflation i.e. whether inflation is accurately forecasted by the banks or not. A significantly positive effect of inflation on profitability is generally interpreted as a good monitoring of future inflation by banks, yielding an accurate adjustment of interest rates and thus resulting in revenues growing faster than costs. In the most recent papers, the effect of inflation on profitability is found significantly positive. The effect of *interest rate spread* relies on the traditional maturity transformation activity of banks, yielding revenues essentially related to loans: banks are assumed to receive and remunerate short-term deposits and allow long-term loans, from which they receive an interest rate. Hence, a higher interest rate spread is likely to impact positively on banking profitability. This effect is to be more significant when tested on the NIM subcomponent of revenues. *Loan growth* is linked to the traditional source of revenue for the banks that is the one stemming from credit distribution. Among the different revenue sources, it is likely to impact positively not only on net interest income, but also on a part of fees related to credit. *Stock market returns* are directly linked to the revenue's subcomponent stemming from trading income. However, it often appears strongly correlated with GDP growth, which makes its study as a determinant of the overall banking profitability difficult, all the more than GDP growth is jointly considered. On the contrary, stock market volatility, which may increase banks' trading opportunities, yields higher non interest income and profitability, or increase provisions because of higher uncertainty and thus leads to smaller profits.

We use the following explanatory variables for our regressions on ROA:

- ‘GDP growth’ is defined as the year-on-year change in the real French GDP in volume, extracted from the OECD database. The choice of the *national* GDP growth is consistent with the choices made by Athanasoglou et al. (2008) and Albertazzi and Gambacorta (2009) among others. It assumes that, even on a consolidated database, profitability of French banks essentially depends on the French growth, irrespective of those of countries where international groups may owe assets. Nevertheless, it seems reasonable, first as French GDP growth does not prove, on average, uncorrelated to that of countries where French banks might owe assets, and second because the international merger and acquisitions of French banks took place only in the very recent years. Another more practical reason lies in that we only can observe the path of French GDP growth in the stress test part of the paper and do not want to impend artificially on the effect of a recession on ROA (conservative assumption on stress tests, see Part 4);
- The ‘inflation’ variable is defined as the year-on-year variation in the French consumer price index;
- The yield curve is the difference between 10-year French Treasury bonds rate and 3-month Euribor (Pibor before 1999) rate;
- The stock market index’s return (volatility) is measured as the year-on-year growth of the SBF250 index’ return (the annual historical volatility of the SBF250 index).

The following figure shows the developments in some of the main macroeconomic variables (GDP growth the yield curve) used in our model.

[Chart 2: evolution of GDP growth and yield curve (1993-2008)]

The following tables 2 and 3 conclude on the one hand on the expected signs and the definition of the tested variables; on the other hand on the descriptive statistics about the macroeconomic, financial and bank-specific variables.

[Table 2: Expected signs of explanatory variables]

[Table 3: Macroeconomic and banking annual data (1993-2008)]

2.4 Model

Our objective is to identify the macroeconomic, financial and bank-specific determinant of banks' profitability. For this purpose, as one may remark from Chart 2, profit seems to persist over time. Hence, we would like to allow for the existence of an autoregressive component of ROA as explanatory variable in line with Berger *et al.* (2000).

We adopt a dynamic model specification including a lagged endogenous variable, to account for persistence. The model is written, for each date t , as:

$$\pi_{i,t} = c + \phi_1 \pi_{i,t-1} + \sum_j \beta^j X_t^j + \sum_k \theta^k Z_{i,t}^k + \varepsilon_{i,t} \quad (1)$$

where c is a constant, i indicates the i -th bank of the sample, X^j indicates the j -th macroeconomic variable which is common to all banks, Z^k indicates k -th bank-specific variable and $\varepsilon_{i,t} = \nu_i + u_{i,t}$ is a residuals composed of a bank-specific fixed effect ν_i and a normal residuals $u_{i,t}$.

2.5 Econometric investigation

Our econometric investigation encompasses essentially four steps.

In a *first* time, we test for the stationarity of the panel, using unit root tests for unbalanced panels (the Levin, Lin and Chu test, complemented by a Fisher test). Results are presented in the following Table 4 and tend to confirm the stationarity of the panel.

[Table 4: results of the stationarity tests for the bank-specific variables]

The stationarity of the macroeconomic variable is also tested using a Dickey Fuller test but is not that relevant given the small number of observations (16 for each series).

[Table 5: results of the stationarity tests for the macroeconomic and financial variables]

All in all, we are confident in that the panel can be considered as stationary.

In a *second* time, we identify whether some explanatory variables might be endogenous. There are two good candidates: apart from the credit risk measure, which will not be retained in the end

because of its insignificance, the capital and the share of non-interest income. Following Athanasoglou *et al.* (2008), we run the model (1) with those variables as strictly exogenous, strictly endogenous or one exogenous and the other endogenous. The Sargan tests appear in favour of considering *nnii* as endogenous and capital as exogenous.

A *third* question that may arise is the treatment of M&A. Following Athanasoglou *et al.* (2008) and Albertazzi and Gambacorta (2009), we chose to disregard any detailed treatment of mergers and acquisitions, and to estimate an unbalanced panel. There may be two reasons for this: first, including a dummy variable for each merger may limit dramatically the number of degrees of freedom of the system; second, as argued by Athanasoglou *et al.* (2008), the capital variable already accounts indirectly for potential M&A effects⁷.

Fourth, as regards the estimation *stricto sensu*, we use the Arellano-Bond (Arellano and Bond, 1991) *two step* estimator for dynamic panel-data models and *robust* option to report standard error, under STATA using command *xtdpd*. We use two types of instruments for our difference equation: all exogenous variables (*X* and *Z*) as additional standard instruments except non

⁷ By way of a robustness check, we re-run our regressions excluding from the dataset the observations corresponding to a year-on-year increase in assets by more than 20%.

This leaves the results unchanged.

interest income (*nii*)⁸ and lagged endogenous variables (π and *nii*) as difference GMM-type instruments. The difference equation used in our model is also:

$$\Delta\pi_{i,t} = \phi_1 \Delta\pi_{i,t-1} + \sum_j \beta^j \Delta X_t^j + \sum_k \theta^k \Delta Z_{i,t}^k + \Delta\varepsilon_{i,t} \quad (2)$$

3. Results

3.1 Baseline equation

Our aim is to estimate the impact of economic and financial shocks on banks' profitability. We begin by considering the whole vector of possible variables, identified from our literature review, that is to say: GDP growth, spread, inflation rate, stock market return, stock market volatility, loan growth, share of non-interest income, capital, expenditures, risk and the constant.

Firstly, we chose stock market index's return as the measure of market activities. However, the coefficient of this variable proves not significant in our regressions, especially when estimated with other macroeconomic variables. Then, we find that the positive coefficients of yield curve and the market index return are not simultaneously significant. Besides, this variable is highly and negatively correlated to inflation, with a correlation coefficient of - 0.63 during the studied

⁸ Non interest income is directly linked with net income. By running several models, regression results show inherently that non interest income is better modelled as endogenous variable.

period (cf. Table 6). For that reason, in the remainder of the paper, we only consider stock market volatility as a proxy for market shock.

[Table 6: coefficient of correlation between macroeconomic and financial variables]

Regarding the other macroeconomic variables, we find that the inflation rate is not significant when combined with GDP growth. That may result from the strong relationship between these two variables. Hence, we decide to remove the inflation rate from the equation. Furthermore, among the banking specific variables, we find that the variables ‘risk’ and ‘expenditures’ are not significant and drop them in the remainder of the paper.

Finally, we get the final results which are presented in Table 7, which are those we will consider in the remainder of the paper as the main equation results.

[Tables 7: Results for the main equation]

The significant coefficient on the lagged endogenous variable confirms the dynamic specification. The coefficient of the lagged ROA, which equals to 0.159, indicates that profitability seems to be moderately persistent over time. According to Athanasoglou *et al.* (2008), a small value of that coefficient means that the industry is fairly competitive (high speed of adjustment).

The regression results confirm our guess that a higher GDP growth, higher yield curve or higher inflation rate (cf. table 7bis) increase banks’ profitability, which are exactly the results that were

expected both from the economic theory and from the empirical results obtained by other studies. The coefficient on GDP growth means that an increase of GDP growth by 1% increases the overall ROA of the whole French banking system by about 0.05%, which is quite significant given the average ROA over the sample (0.67%). The same reasoning applies to the yield curve. Contrary to the market index' return, market index' volatility is negatively linked with banking profitability. An interpretation is that higher stock market volatility is associated with higher uncertainty, leading to smaller profits. To test whether the relationship is still relevant when the economic growth slows down, we re-run the main equation presented in the table 7 with a cross-variable which equals the economic growth times a time dummy for period when economic growth was less than 2%⁹. Results remain unchanged, stating the robustness of the result.

As regards the effects of banking structure to banking global profitability, we observe that both the leverage ratio (the inverse of the capital-to-asset ratio included in our estimation) and the non interest income have a positive effect on banking profitability. The intensity in the use of capital increases banks' profitability can be interpreted as a proxy for the "efficiency" of the capital, particularly important in banks' risky businesses. Besides, we find evidence that small banks have higher ROA than other banks.

3.2 Back testing of the results

⁹ Specifying a dummy only for recessions, for instance, does not make sense, as there is no actual recession over the sample. Hence, we set the dummy so as to capture modest growth with a reasonable number of observations, here 6 years out of 16 included in the whole sample.

In order to analyse the quality of our model, the following standard tests for linear dynamic panel model have been presented in the result table of each regression: Wald-test indicates jointly signification of coefficients of explanatory variables; the Sargan-test shows no evidence of over-identifying restrictions; the negative statistic value for the first-order autocorrelation test on errors is expected in dynamic panel model; the second-order autocorrelation test on errors have been rejected so that there is no problem of autocorrelation AR (2) on errors.

In addition, the following table 8 and chart 3 give additional information on the quality of the model. The table 8 shows that first and second moments of actual and estimated ROA plea for the robustness of the regression over the whole sample (2146 observations). The Chart 3 proves that the model is able to replicate the broad dynamics of the actual path of the aggregate ROA.

[Table 8: Results of back testing]

[Chart 3: path of average ROA]

3.3 Additional robustness checks

3.3.1 Baseline equation re-estimated with group-effects

As shown in Table 1, the panel used may exhibit slight differences in the behaviour of subsamples of the panel. In this subsection, we re-estimate the main equation with specific effects linked to the legal status or to the size on the individuals.

Individual effects linked with banks' legal status

We estimate a further regression for ROA where the variable GDP growth has been substituted by GDP growth times indicators ($X^l I_q$), which are dummy variables on banks' legal status. The aim is to test the differentiated effects of banks' legal status in events of macroeconomic shocks.

$$\pi_{i,t} = \phi_1 \pi_{i,t-1} + \sum_l \beta^l X_t^l + \sum_k \theta^k Z_{i,t}^k + \sum_q \delta_q GDP_t I_q + \varepsilon_{i,t} \quad (3)$$

I_q : q-th dummy variable; for example, $I_{bmc} = 1$ for mutual and cooperative banks, 0 otherwise.

The table 9 presents the results for this variant.

Our main findings are that mutual and cooperative banks appear less impacted by GDP growth shocks than commercial banks, with a sensitivity of 0.002 against 0.08, which tend to prove that mutual banks' profits are hardly impacted by the business cycle.

[Table 9: Results for the equation with individual effects linked with banks' legal status]

Individual effects linked with banks' balance-sheet size

We differentiate banks' size according to the size of their balance-sheet; banks that are in the 75%-100% percentile region of the largest balance-sheet are classified as large banks, and banks in the bottom 25% percentile region are classified as small banks.

Our main finding (cf. Table 10) is that small banks seem to be more affected than other banks by shocks on GDP growth.

[Table 10: Results for the equation with individual effects linked with banks' balance-sheet size]

All in all, the results of that subsection 3.3.1 can be summarized in that we do not exhibit a clear homogeneity of the panel as regards the sensitivity of each category's ROA to GDP growth. Nevertheless, as our goal is to study the resilience of the *whole* French banking system to adverse macroeconomic scenarios, we will consider only the results of the main equation in the remainder of the paper.

3.3.2 Restricting the time-window

As a complementary robustness check, we propose to re-run the main equation on a narrower time-window that would cover the period 2000-2008. A reason for choosing that period lies in that some authors exhibit a different behaviour of ROA's reaction to macroeconomic variables after 1999 because of:

- i) the introduction of the euro;
- ii) a different business model of banks;

- iii) a growing influence of securitization, that would threaten the old model of profits through maturity transformation, and thus alter especially the sensitivity of ROA to spread fluctuations.

The results presented in the table 11 clearly plea for the robustness of the model, as regards the magnitude of the coefficients, even if the significance of the coefficients is slightly altered. But for our stress testing purpose (Part 4), only the magnitude of the various coefficients matters.

[Table 11: Results for the main equation (2000-2008)]

4. Macroeconomic stress-tests of French banks' profitability

Stress-tests focused on banking profitability seek to identify most important economic and financial channels of contagion of an initial shock that may affect the stability of the banking sector. Indeed, as the precedent section showed, economic and market environment may affect banks' profitability. The aim of stress test exercises is to study the effects of some macroeconomic or financial variables paths derived from various scenarios – a forecast and some adverse variants - on relevant banking variables, such as profitability.

4.1 Stress-testing banks' profitability

The approaches by Lehmann and Manz (2006) and Rouabah (2006), focusing on Swiss and Luxemburg respectively, conclude that the impact of macroeconomic and financial shocks on banks' profits is relatively modest, showing that the two banking sectors are resilient. But the

analysis carried out in those papers, albeit interesting, is limited to sensitivity analysis and does not consider a comprehensive scenario.

Here it is very important to notice that our aim is not to only study the impact of one shock of one specific explanatory variable on the income subcomponents, regardless of the impact of such a shock on the other variables. On the contrary, the impact of stress scenarios on the relevant risk factors is consistently determined with the Banque de France's macroeconomic models (*Mascotte* and *Nigem*). This means that, conditionally on a specific scenario, we get some “stressed” output variables of the macroeconomic model (our “stressed” explanatory variables), which are then used as “stressed” inputs in our banking models for the revenue. Hence, we get “stressed” profitability, which is compared to the value got without any stress (i.e. in line with the basis line of the macroeconomic forecast). The advantage of using such a macroeconomic model is that it offers a lot of flexibility in the design of the scenario and that it ensures the consistency of the forecasted and stressed paths of the various macroeconomic variables.

A limitation to this approach lies in the feature of traditional macroeconomic model. Even though it provides an integrated and consistent framework to link the different effects of exogenous shocks on key macro variables such as GDP growth, loans or interest rates, the model is not clearly devoted to analyse financial relationships and how different agents in the system may be financially constrained. In other words, in such models, there is no limit to credit demand from households, which is in turn always satisfied. Another limitation is related to the fact that our model does not aim at taking into account of “second round” effects, as it only captures the effect of macroeconomic shocks on banking variables and not directly that of banking variables

on macroeconomic and financial ones. In addition, our stress test exercises are carried out all other things being equal: in particular, we do not model any portfolio reallocation, leading to a shift from interest income to trading income, in case of, for instance, a negative shock on the spread, leading to a decrease of net interest revenues. For those reasons, it seems much more relevant to restrict our stress test exercise to the first year of shock, given that it is likely to avoid any unreliable result.

4.2 Model specification choice and stress-testing banks' earning structure

The macroeconomic baseline scenario stems from the Broad Macroeconomic Projection Exercise for France, which is produced by the DG Economics of the Banque de France. Stressed scenarios are defined as severe but plausible in comparison with baseline scenario. At the juncture of April 2009, we design and test five (severe but plausible) hypothetical stress scenarios:

- Internal demand shocks: - 1% GDP growth, - 2% GDP growth, - 3% GDP growth;
- Financial shocks: a 25% depreciation of the dollar against the euro; a flattening of the yield curve (- 200 bp Euribor 3M and – 400 bp OAT 10Y)

The impacts of the stress scenarios on the relevant macro risk factors (GDP, loan growth, interest rates) for the years 2009-2010 are determined by using Banque de France macroeconomic models (Mascotte [Baghli *et al.*, 2005] & NIGEM, the latter being provided by the NIESR and used to introduce international interactions).

Table 12 presents the effects of those scenarios on the variables used as inputs in our profitability models. Table 13 presents the results of stress tests using the baseline model presented in the table 7.

[Table 12: design of scenarios]

[Table 13: results of stress tests using the baseline model]

First, our results show that the French banking system would be somewhat resilient to comprehensive adverse scenarios. Only the severe recession scenarios (-2% growth and -3% growth) would generate negative profits. On the contrary, other scenarios would be consistent with positive profits. Looking at the actual figures for French banking system over the first semester 2009, those results stemming from the stress test scenarios, which may appear optimistic, are consistent with the publications of banks. Indeed, as the GDP growth forecast for 2009 is likely to be in the range [-2.4%;-2%] (cf. for instance recent OECD's and IMF's outlooks), our -2% stress scenario constitute a good benchmark. The annual ROA of 0% forecasted by the model is not that far from the actual figure for the first semester, which equals 0.07% for the six main French banks taken together. This means that the diagnosis of relatively good results recorded by the French banking system in the context of the current crisis could have been rather accurately forecasted by the model, especially relative to the mean of ROA over the sample (0.67%). This might be seen as some kind of robustness or backtesting check.

In addition, we study the distribution of GDP growth from 1875 to 2008 excluded the war years in order to calibrate the probability of recession (cf. chart 4). It is clear from the results of non

autocorrelation tests (cf. table 14) that the GDP growth is a White Noise process. Moreover, the GDP growth does not follow a Normal distribution according to the normality tests (cf. table 15). Thanks to the distribution of GDP growth, we simulate the probability of the three recession scenarios defined previously. According to this distribution, the average value of GDP growth is 2.7% and the cumulative probability associated is about 58%. Hence, the probability that the GDP growth is greater than the average value is equal to 42%. We get that the probability of GDP growth to be smaller than -1% is 14%, 2% is 8% and -3% is 5% (cf. Table 16).

In addition, the first actual figure obtained for French banks' ROA, 0.063%, is close to that obtained by simulating our model using the actual path for explanatory variables, giving grounds to the robustness of our model.

5. Conclusion

Our results provide evidence of statistically significant relationships between the macro environment and the profitability of the banking industry. In particular, we give evidence of a robust result according to which overall French banking system's profitability depends positively on the French GDP growth, the stock market return and the maturity spread, the share of non-interest income and the capital owed by banks, and negatively on the banking size and credit risk. Those results are fully consistent with those of the related economic literature.

Our stress testing analysis suggests that the impact of economic shocks may be relatively modest in terms of profitability, the French banking system being quite resilient and well capitalized to absorb extreme macroeconomic and financial variations. In particular, the model would have

performed in a good manner to forecast the good results of the French banks in spite of the current depressed juncture.

However, a lot of work remains to be done, as other risk channels may affect banks' profits but are not simulated in that framework, such as the sudden illiquidity in specific banking activities observed in August 2007 at the beginning of the subprime crisis (illiquid structured products, tensions in the money market). Moreover, the model may be refined in terms of econometrics, as it fails to explicitly include non-linearities that may arise in extreme events, and the macroeconomic forecasting model does not provide us with paths for the financial variables.

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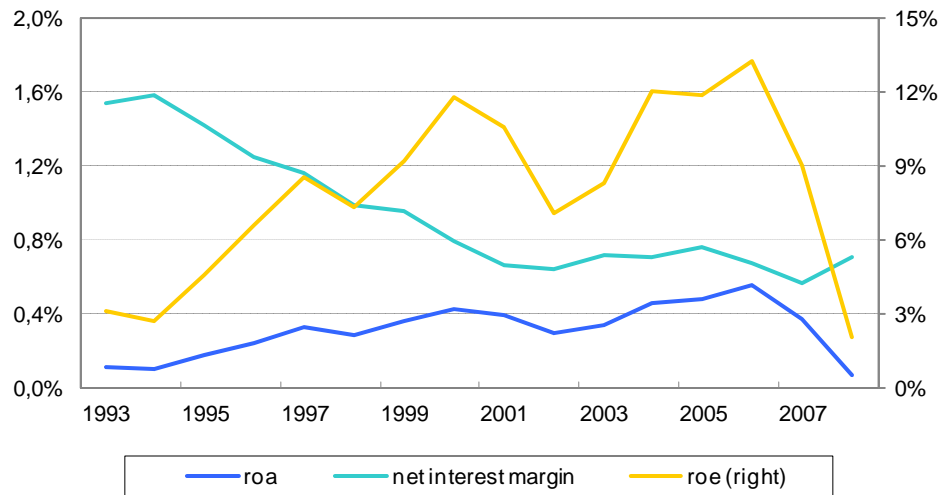
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Chart 1: evolution of banks' profitability (1993-2008)



Coefficient of correlation	ROA	Net interest margin	ROE
ROA	1		
Net interest margin	-0.61	1	
ROE	0.93	-0.59	1

Chart 2: evolution of banks' profitability, GDP growth and yield curve (1993-2008)

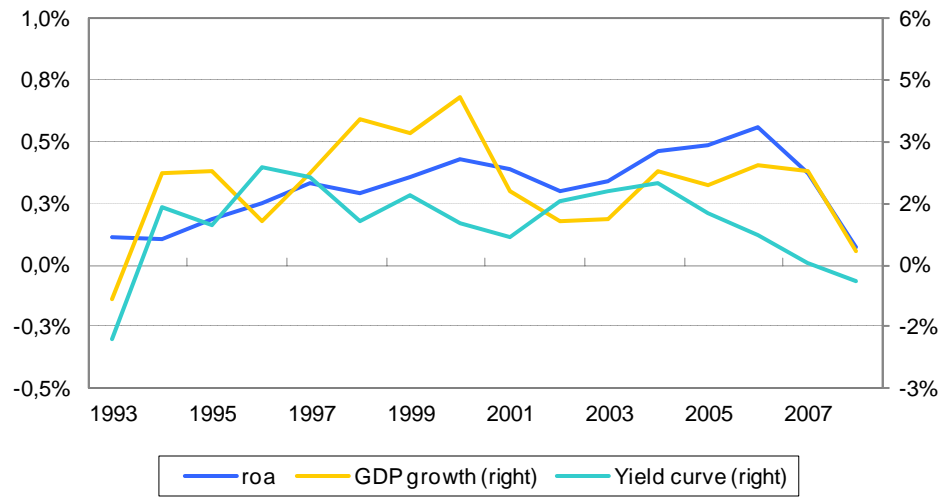


Chart 3: path of average ROA

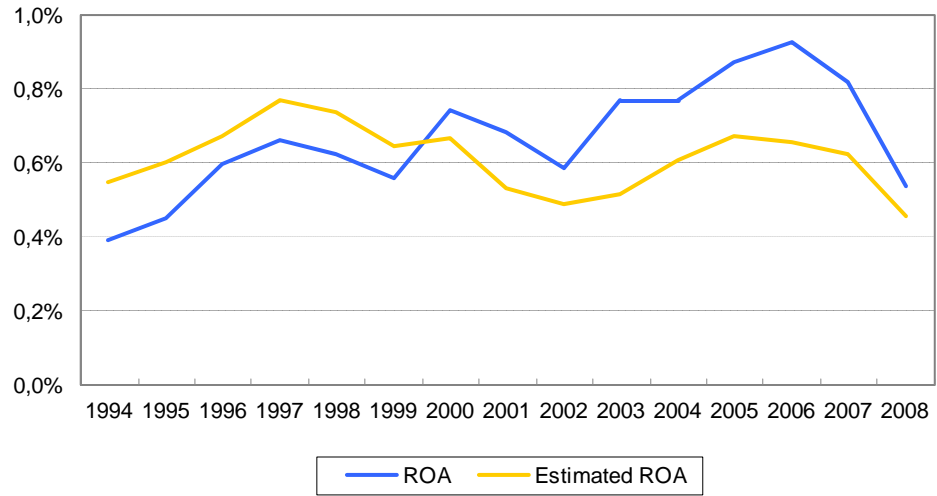


Chart 4: Distribution of GDP growth

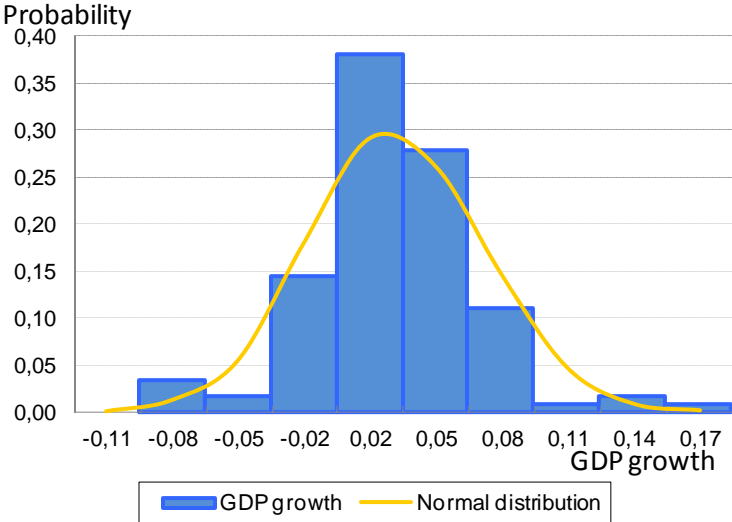


Table 1: descriptive statistics of ROA

1993-2008	All banks	Commercial banks	Mutual and cooperative banks	Financial and investment firms
<i>ROA</i>				
Average	0.7%	0.6%	0.6%	0.9%
Std.	0.7%	0.7%	0.3%	1.0%
Min	-1.5%	-1.4%	-0.7%	-1.5%
Max	3.9%	3.8%	3.2%	3.9%
Observations	2720	862	998	860
<i>Capital / assets</i>				
Average	10%	8%	8%	14%
Std.	12%	13%	4%	15%
Min	-3%	0%	-3%	0%
Max	4%	265%	31%	97%
<i>Non interest income /assets</i>				
Average	2%	2%	2%	4%
Std.	8%	3%	1%	13%
Min	-16%	-16%	0%	-3%
Max	265%	33%	7%	204%
<i>Expenditures / assets</i>				
Average	3%	3%	2%	4%
Std.	7%	3%	1%	12%
Min	0%	0%	0%	0%
Max	204%	30%	6%	187%
<i>Individual net operating income /total operating income</i>				
Average	0.6%	1.1%	0.4%	0.2%
Std.	1.9%	3.0%	1.1%	0.7%
Min	0%	0%	0%	0%
Max	187%	20%	11%	10%
<i>Loans / assets</i>				
Average	91%	91%	93%	88%
Std.	11%	8%	4%	17%
Min	4%	4%	62%	4%
Max	20%	100%	98%	100%
<i>Loan loss provisions / loans</i>				
Average	3%	4%	2%	4%
Std.	7%	8%	2%	10%
Min	0%	0%	0%	0%
Max	100%	96%	22%	133%

Table 2: Expected signs of explanatory variables

Variable	Specifications	Notation	Exp. Sign
<i>Dependent variable</i> Profitability	Net profits after taxes / assets	ROA	
<i>explanatory variables</i>			
Output	GDP annual growth	GDP	+
Inflation	Annual inflation rate	Cpi	+
Loan	Annual growth rate of aggregated loans	Loan	+
Yield curve	Difference between OAT10y and Euribor 3m	Spread	+
Financial market return	SBF 250 index's annual return	Sbf	+
Financial market volatility	Volatility of the SBF 250 index's annual return	Volsbf	-
Large banks	Dummy variable for large banks	Large	-
Small banks	Dummy variable for small banks	Small	+
Capital	Capital over assets	Capital	+
Credit risk	Loan loss provisions / loans	Risk	-
Market power	Individual net operating income / total net operating income of the banking industry	P_NoI	+
Non interest income	Non interest income / total assets	NNII	+

Table 3: Macroeconomic and banking annual data (1993-2008)

Macroeconomic data (1993-2008)				
	Average	CV	Min	Max
GDP growth	1.92%	0.63	-0.87%	4.08%
Spread	1.02%	1.04	-1.82%	2.37%
Loan	4.75%	0.88	-1.27%	11.75%
Inflation	1.7%	0.33	0.50%	2.81%
SBF250 return	7.3%	3.40	-41.61%	49.5%
SBF250 volatility	18.3%	0.43	9.62%	38.3%

Table 4: results of the stationarity tests for the bank-specific variables

Variable	Levin, Lin & chu		Fisher test	
	W-stat	p-stat	χ^2	p-stat
ROA	-16	0.00	427	0.01
Capital	-164	0.00	441	0.00
NNII	-166	0.00	474	0.00

Table 5: results of the stationarity tests for the macroeconomic and financial variables

Dickey-Fuller ERS			
Variables	T-stat	1% critical value	10% critical value
GDP growth	-2.73	-2.73	-1.60
Spread	-2.7	-2.73	-1.60
Loan growth	-1.39	-2.73	-1.60
Inflation	-1.82	-2.73	-1.60
SBF return	-2.42	-2.73	-1.60
SBF volatility	-1.65	-2.73	-1.60

Table 6: coefficient of correlation between macroeconomic, financial and banking variables

	roa	L.roa	gdp growth	spread	loan	cpi	sbf	volsbf	L.volsbf	capital	risk	nnii	large	small	expenditure	p_noi
roa	1.00															
L.roa	0.69	1.00														
gdp growth	0.04	-0.06	1.00													
spread	0.01	-0.13	0.34	1.00												
loan	0.15	0.17	0.32	-0.22	1.00											
cpi	0.01	0.08	-0.69	-0.28	0.00	1.00										
sbf	0.02	-0.06	0.30	0.29	-0.08	-0.63	1.00									
volsbf	-0.02	0.05	-0.09	-0.25	0.20	0.20	-0.59	1.00								
L.volsbf	-0.01	-0.01	-0.09	0.12	-0.02	0.00	-0.05	0.38	1.00							
capital	0.30	0.26	-0.01	0.00	0.02	0.02	0.00	-0.01	-0.02	1.00						
risk	0.08	0.02	-0.01	0.06	-0.08	-0.03	0.03	-0.03	0.03	0.20	1.00					
nnii	0.21	0.11	-0.02	0.02	0.03	0.03	0.01	0.02	-0.02	0.29	0.15	1.00				
large	-0.18	-0.17	-0.09	-0.12	0.19	0.14	-0.11	0.10	-0.01	-0.21	-0.15	-0.09	1.00			
small	0.13	0.07	0.05	0.11	-0.18	-0.10	0.10	-0.10	-0.07	0.34	0.26	0.19	-0.33	1.00		
expenditure	0.17	0.09	-0.02	0.02	0.00	0.03	0.01	0.01	-0.03	0.28	0.15	0.98	-0.13	0.20	1.00	
p_noi	-0.10	-0.12	-0.04	-0.04	0.01	0.04	-0.02	0.00	-0.01	-0.13	-0.07	-0.04	0.41	-0.17	-0.05	1.00

Tables 7: Results for the main equation

Arellano-Bond dynamic panel data estimation (t= 1993 - 2008)		
Number of Obs. = 2146		
Number of groups = 363		
ROA	coef.	p
Lag1 (Roa)	0.159*	0,053
GDP growth	0.048***	0,000
Spread	0.039***	0,005
L1. SBF volatility	-0.0001***	0,009
Small	0.003**	0,035
Capital	0.012***	0,003
NNII	0.051**	0,047
Wald test	chi2(7)=71	p>chi2 = 0,00
Sargan test of over-identifying inst.	chi2(208)=211	p>chi2 = 0,42
Autocorrelation test AR(1)	z=-2.86	p>z=0,00
Autocorrelation test AR(2)	z=0.25	p>z=0,80
Overall R ²	38%	
Between R ²	49%	
Within R ²	16%	

Table 7bis: Results for the main equation with insignificant variables

Arellano-Bond dynamic panel data estimation (t= 1993 - 2008)		
Number of Obs. = 2146		
Number of groups = 363		
ROA	coef.	p
Lag1 (Roa)	0.158*	0,054
GDP growth	0.060***	0,000
CPI	0.033	0,141
Spread	0.037**	0,013
L1. SBF volatility	-0.00001***	0,010
Small	0.003**	0,039
Large	-0.001	0,262
Capital	0.012***	0,003
NNII	0.051**	0,046
Market power	0.010	0,872
Wald test	chi2(10)=76	p>chi2 = 0,00
Sargan test of over-identifying inst.	chi2(208)=215	p>chi2 = 0,35
Autocorrelation test AR(1)	z=-2.88	p>z=0,00
Autocorrelation test AR(2)	z=0.31	p>z=0,76
Overall R ²	38%	
Between R ²	51%	
Within R ²	16%	

Table 7ter: Results for the main equation testing whether the relationship is still relevant when the economic growth is modest

Arellano-Bond dynamic panel data estimation (t= 1993 - 2008)		
Number of Obs. = 2146		
Number of groups = 364		
ROA	coef.	p
Lag1 (Roa)	0.157*	0.056
GDP growth	0.056***	0.000
Spread	0.037***	0.008
L1. SBF volatility	-0.0001***	0.007
Small	0.003**	0.035
Capital	0.012***	0.003
NNII	0.051**	0.047
Modest growth-year ¹⁰ * GDP	0.021	0.138
Wald test	chi2(8)=86	p>chi2 = 0.00
Sargan test of over-identifying inst.	chi2(208)=214	p>chi2 = 0.38
Autocorrelation test AR(1)	z=-2.84	p>z=0.00
Autocorrelation test AR(2)	z=0.21	p>z=0.83

¹⁰ Modest growth-year is a dummy that is equal to 1 if the GDP growth of the year is less than 2%. In our case, the modest growth years are 1996, 2001, 2002, 2003, 2005 and 2008.

Table 8: Results of back testing

Variable	obs	Std.			
		Mean	Dev.	Min	Max
Actual ROA	2146	0.67%	0.64%	-1.48%	3.90%
Estimated ROA	2146	0.62%	0.39%	-0.37%	7.81%

Table 9: Results for the equation with individual effects linked with banks' legal status

Arellano-Bond dynamic panel data estimation (t= 1993 - 2008)		
Number of Obs. = 2147		
Number of groups = 364		
ROA	coef.	p
Lag1 (Roa)	0.160*	0.054
Spread	0.049***	0.001
L1. SBF volatility	-0.0001***	0.001
Small	0.003**	0.029
Capital	0.012***	0.003
NNII	0.050**	0.050
Bank*GDP	0.081***	0.001
Cm*GDP	0.002	0.845
IF*GDP	0.090***	0.008
Wald test	chi2(9)=72	p>chi2 = 0.00
Sargan test of over-identifying inst.	chi2(208)=219	p>chi2 = 0.29
Autocorrelation test AR(1)	z=-2.83	p>z=0.00
Autocorrelation test AR(2)	z=2.44	p>z=0.81

Table 10: Results for the equation with individual effects linked with banks' balance-sheet size

Arellano-Bond dynamic panel data estimation (t= 1993 - 2008)		
Number of Obs. = 2147		
Number of groups = 364		
ROA	coef.	p
Lag1 (Roa)	0.165**	0.042
Spread	0.049***	0.000
L1. SBF volatility	-0.0001***	0.003
Capital	0.013***	0.002
NNII	0.054**	0.040
Large*GDP	0.041***	0.001
Average*GDP	0.031**	0.029
Small*GDP	0.116***	0.004
Wald test	chi2(8)=76	p>chi2 = 0.00
Sargan test of over-identifying inst.	chi2(208)=208	p>chi2 = 0.48
Autocorrelation test AR(1)	z=-2.86	p>z=0.00
Autocorrelation test AR(2)	z=0.25	p>z=0.80

Table 11: Results for the main equation (2000-2008)

Arellano-Bond dynamic panel data estimation (t= 2000 - 2008)		
Number of Obs. = 1218		
Number of groups =240		
ROA	coef.	p
Lag1 (L.Roa)	0.114*	0,098
GDP growth	0.046**	0,011
Spread	0.051***	0,005
L1. SBF volatility	-0.0001**	0,013
Small	0.003*	0,093
Capital	0.011***	0,005
NNII	0.055**	0,050
Wald test	chi2(7)=70	p>chi2 = 0,00
Sargan test of over-identifying inst.	chi2(178)=183	p>chi2 = 0,38
Autocorrelation test AR(1)	z=-3.22	p>z=0,00
Autocorrelation test AR(2)	z=0.71	p>z=0,48
Overall R ²	28%	
Between R ²	32%	
Within R ²	20%	

Table 12: design of scenarios

In deviation from the basis line		GDP growth	
		T+1	T+2
1	- 1% GDP growth	-0.8	-2.1
2	- 2% GDP growth	-2.1	-3.0
3	- 3% GDP growth	-2.7	-4.0
4	- 25% depreciation of USD/EUR	-0.6	0.0
5	Flattening of the yield curve	0.0	0.4

Table 13: results of stress tests using the main equation results

ROA	-1% GDP growth	-2% GDP growth	-3% GDP growth	-25% depreciation of USD/EUR	Flattening of the yield curve (-200bp ST, -400bp LT)
T+1	0.07%	0.00%	-0.03%	0.08%	0.03%
T+2	0.01%	-0.04%	-0.10%	0.12%	0.05%

Table 14: White Noise test for GDP growth

Autocorrelation check for White Noise			
To lag	Chi-square	DF	Pr>Khi 2
6	9.65	6	0.14
12	10.85	12	0.55
18	19.12	18	0.39
24	26.33	24	0.34
30	27.83	30	0.58

Table 15 : Normality test

Normality tests		
Test	Statistique	p value
Shapiro-Wilk	W= 0.96	Pr > W=0.001
Kolmogorov-Smirnov	D= 0.09	Pr> D=0.03

Table 16: Calculation of expected ROA

GDP growth	Prob.	GDP growth	Prob.	St prob.	ROA (N+1)	ST ROA (N+1)
> 2.7%	42%					
>-0.3%	80%	>-0.3%	80%	42%	>0.11%	0.11%
>-1%	86%	[-1%, -0.3% [	6%	6%	[0.11%, 0.07% [	0.07%
>-2%	92%	[-2%, -1% [	6%	6%	[0.00%, 0.07% [	0.00%
>-3%	95%	[-2%, -3% [	3%	3%	[-0.03%, 0.00% [	-0.03%
Average						0.049%