

Article

# Stress-testing banks' profitability: the case of French banks

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# Executive summary

## **Stress-testing banks' profitability: the case of French banks**

by **Jérôme Coffinet**, Head of Statistical Engineering Division, Directorate General Statistics, Banque de France, and **Surong Lin**, Economist, Banque de France

Over the last decades, banking systems of developed countries have experienced major changes regarding their sources of revenue. Ensuring the banking system's solvency and identifying the vulnerabilities of banks' profitability are crucial. This article presents a stress-testing framework to evaluate the sensitivity of banks' profitability to plausible but severe adverse macroeconomic shocks. The results suggest that there is a statistically significant relationship between the macro environment and the profitability of the banking industry. Looking specifically at the resilience of French banks between 1993 and 2009, the findings show that, even in a severe recession, the French banking system would remain profitable.

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# Stress-testing banks' profitability: the case of French banks<sup>1</sup>

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## Abstract

We propose a stress-testing framework to evaluate the sensitivity of banks' profitability to plausible but severe adverse macroeconomic shocks. Specifically, we test the resilience of French banks' profitability over the period 1993-2009. First, we identify the macroeconomic and financial variables (GDP growth, interest rate maturity spread, stock market's volatility) and bank-specific variables (size, capital ratio, ratio of non-interest income to assets) that significantly determine banks' profitability. Second, we propose macroeconomic stress-testing exercises showing that French banks' profitability is resilient to major adverse macroeconomic scenarios. Specifically, our findings highlight that even severe recessions would leave the French banking system profitable.

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<sup>1</sup> The opinions expressed in the paper do not necessarily represent those of the Banque de France or the French Prudential Supervisory Authority.

## Introduction

Over the last decades, banking systems of developed countries have experienced major changes regarding their sources of revenue. The traditional interest revenue has been increasingly replaced by fees and commissions, and trading incomes. According to some observers, this development could lead to a 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 as a whole proved profitable even through the crisis.

From the supervisory perspective of 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 banks' profitability is likely to be transmitted to the solvency ratios, eventually 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, combined with difficulties to issue additional equity, are likely to ration credit in order to meet regulatory constraints, and finally to weigh on the economic growth. Third, profits are known to be reliable early-warning indicators of financial distress [Demirgüç-Kunt and Detragiache (1999)], though they are available, at best, on a quarterly basis. The low profitability data frequency, combined with their backward-looking nature, makes it fundamental for regulators to identify the main determinants of profits in order to run accurate forecasts and determine vulnerabilities in a more forward-looking manner.

The early research dedicated to banks' earnings sources focuses on net interest margins [Ho and Saunders (1981)]. In that respect, Allen (1988), Saunders and Schumacher (2000), and Demirgüç-Kunt and Huizinga (2000) highlight a robust relationship between interest margins and the business cycle. Nevertheless, the growing importance of non-interest income (fees and commissions, and trading incomes) progressively lessens the importance of net interest income. On average, the share of income generated by traditional interest activities has progressively fallen in the U.S. and in Europe over the two last decades. Consequently, recent research has focused on the determinants of bank profitability accounting for both interest

and non-interest activities. Alternatively, the literature on bank interest margins has considered the impact of non-interest activities on optimal loan price and margin setting [Carbo Valverde and Rodriguez Fernandez (2007)]. In this paper, because we are concerned about the safety and soundness of the banking system and the ability of individual banks to generate income to prevent sharp equity changes, we focus on aggregate profit measures such as the return on equity (ROE) and the return on assets (ROA). Earlier work on bank profitability has focused on three types of determinants which are generally found as significant determinants of banks' profitability: firm-specific variables (the amount of capital, bank expenditures, the size of the bank proxied by its total assets, and the risk borne 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, and the share of non-interest income), as established by Smirlock (1985), Berger (1995), and Lepetit et al. (2008); and finally macroeconomic and financial variables (GDP growth, interest rate spread, inflation, stock market's return and volatility, and loan growth), as established, among others, by Revell (1979), Molyneux and Thornton (1992), Demirgüç-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, we rely on the recent stress-testing frameworks developed by supervisors and central banks over recent years. In contrast to the methods implemented by banks themselves, those implemented by supervisors focus 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 as particularly relevant tools to assess the effects of adverse scenarios on banks' profitability, like our paper's objective, since 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 identify the main determinants of French banks' profitability

– measured by their return-on-assets (RoA) – by considering the most relevant macro and bank-specific factors used in the literature. Second, we develop an innovative stress-testing framework to evaluate the resistance of French banks' RoA 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, although Goyeau et al. (1998) and Goyeau et al. (2002) extend the model developed by Flannery (1981) to analyze the profitability of French banks their focus is on the sensitivity of bank profits to interest rate changes. To our knowledge, our paper is the first to use individual supervisory bank data to study the determinants of French banks' profits and their sensitivity to changes in the economic environment as a whole and therefore accounting for a large number of macro variables, such as interest rates but also GDP growth, inflation, stock prices, and exchange rates.

Our results show that banks' profitability significantly depends 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). However, simulating major macroeconomic shocks and looking at the magnitude of their effects on banks' profitability, we find that French banks' profitability is resilient to major adverse macroeconomic scenarios. These 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.

## Data and empirical model

### Data

In this paper, bank-specific variables come from the supervisory dataset BAFi, consisting of a panel of individual French banks' consolidated data over a relatively long period (1993-2009) on an annual basis. The dataset, called 'BAFi,' which stands for 'Base des Agents Financiers' (Basis of financial agents), belongs to the French banking supervisor (Prudential Supervisory Authority). Relying on such supervisory data allows us to consider the whole French banking system on a consolidated basis in a comprehensive manner. In particular, it turns out that the quality of the data with

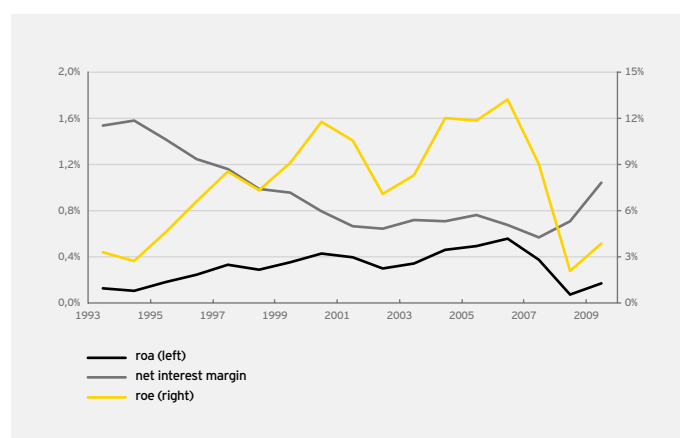


Figure 1: Evolution of banks' profitability (1993-2009)

Coefficient of correlation	RoA	Net interest margin	RoE
ROA	1		
Net interest margin	-0.60	1	
ROE	0.93	-0.59	1

regards to non-interest and, specifically, trading income appears much better than that of private data providers, especially at the very beginning of the sample. 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 370 different groups over the whole sample, about 170 on average each year.

### Dependent variable

Our dependent variable is banks' profits. Alternative profitability measures could be considered for the purpose of this study, such as RoA, defined as the ratio of the net income after taxes to total assets, and return-on-equity (RoE), defined as the ratio of the net income after taxes to total equity. Net interest margin, defined as the ratio of the net interest income after taxes to total assets could also be used as a proxy. However, as the net interest margin is solely based on interest activities, whose importance in terms of the share of total income has experienced a continuous decline over the recent years [Coffinet et al. (2009)] and does not constitute an aggregate measure of profitability, we do not consider it as a relevant endogenous variable for the purpose of this paper.

With regards to ROE and ROA, the latter is more consistent with supervisory concerns than the former. First, it is directly related to the quality of loans, as opposed 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, to some extent there might be 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, 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 specifically most French banks. Hence, we focus on ROA as the key ratio for evaluating banks' profitability, which is consistent with our supervisory objectives and the recommendations of the International Monetary Fund (2002) and numerous studies like, for instance, Athanasoglou et al. (2008).

Figure 1 displays the evolution of banks' profitability during the period under consideration according to these three measures after removing outliers, defined as observations beyond the 95% percentile and below the 5% percentile.

From the outset, one notices that the overall French banking system's RoA seems to move in tandem with the business cycle, falling significantly in the years 1993-1994, 2001-2002, and 2007-2009, coinciding with economic slowdowns or downturns, and increasing in the periods 1994-2000 and 2003-2006, corresponding to robust economic growth. Besides, Figure 1 shows that RoA and RoE behave in a very similar manner over the whole sample period. The correlation between both series is very high (93%). Hence, we can infer from that figure that results obtained on the basis of RoA figures are robust to the choice of the profitability measure (RoA versus RoE). On the contrary, as expected, NIM is less correlated to RoA and RoE, and behaves in an opposite manner (as shown by the negative sign of the correlation coefficients). This demonstrates that the aggregate profitability of banks is, over the sample period, more strongly linked to non-intermediation activities than to traditional interest revenues.

Nonetheless, the French banking system is composed of institutions with different legal statuses, such as commercial banks, financial and investment firms, and mutual and cooperative banks. The

sample (Table A1 in the Appendix) seems well balanced between different types of institutions with, for a total of 2896 bank-year observations, 920 commercial banks, 1070 mutual and cooperative banks, and 906 for financial and investment firms. The average RoA for the whole French banking system was 0.67%. It is homogenous across the three groups and ranges from 0.55% for commercial banks to 0.88% for financial and investment firms. The standard deviation of ROA for financial and investment firms is more than twice that for mutual and cooperative banks, indicating a greater degree of heterogeneity among members of the former group. Moreover, consistent with the empirical literature, we find that smaller banks generate higher RoA and, in accordance with the too-big-to-fail hypothesis, are generally better capitalized.

### Independent variables

With regards to bank-specific determinants of banks' profitability, the related literature generally considers the amount of capital, the size of the bank, the risk borne by the bank, and the expenditures of the bank as suitable proxies [Goddard et al. (2004); Kosmidou et al. (2006); Athanasoglou et al. (2008); Albertazzi and Gambacorta (2009)]. The amount of capital is likely to positively impact 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 have been strengthened by the M&A activities that took place in the late 1990s. A high capital ratio may be viewed as a signal that bank expects high profitability. The size of the bank could be a possible determinant of its profitability, as size can be considered a proxy for capital adequacy, since large banks can raise capital at a lower cost. Nevertheless, the empirical evidence is mixed and sometimes points to a significantly *negative* relationship between size and profitability. A possible interpretation might be that large banks could experience negative effects due to bureaucratic reasons. Conversely, too-big-too-fail considerations may lead to a positive relationship. In terms of the *risk borne by the bank*, it is generally accepted that an increase in exposure to credit risk would decrease a bank's profitability. The risk proxy mostly used in the literature is the ratio of loan-loss provisions to total loans and is specific to credit risk, which might not be as relevant given the growing share of non-interest income in total income. In the literature, this 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* proxy assumes that firms with large market shares and differentiated products are able to use their market power and enjoy a more secured income position. Another possible source of profitability is linked to the *source of revenues*: ceteris paribus, 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. Hence, in this paper, we also control for business differences.

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 "nnii" is the ratio of the sum of fees and commissions, trading income, and dividends to total assets.<sup>2</sup>
- ▶ 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" variable 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 that can also affect banks' performances. They are the same across banks and hence represent many of the cross-sectional common factors. Six macroeconomic and financial variables are generally considered: economic growth, inflation, interest rate spread (split or not between short-term and long-term), stock index return and volatility, and loan growth. There are several reasons why output *growth* may have a positive impact of bank profitability. First, higher growth may result in a higher loan distribution (increased demand) and indirectly higher revenues from financial markets, due to higher stock market returns. Second, with expectations of higher profits, provisions could decrease in economic upturns

<sup>2</sup> 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, these measures do not lead to robust results in our regressions, or make the other variables' significance less robust. Hence, we decided to rely on that 'nnii' measure, yielding very robust specifications of the model, and already used by Smith et al. (2003) and DeYoung and Rice (2004).

and hence capital may have a positive impact on profitability. Empirically, many studies find a significantly positive relationship between GDP growth and banking profitability. However, the effect of *inflation* on profitability is ambiguous and depends on whether the bank's expenses grow faster 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 predictor of future inflation by banks, yielding an accurate adjustment of interest rates and thus resulting in revenues growing faster than costs. In most recent papers, the effect of inflation on profitability is found to be significantly positive. The implications of the *interest rate spread* are related to the traditional maturity transformation activity of banks, yielding revenues essentially related to loans. Banks are assumed to receive and remunerate short-term deposits and grant long-term loans, from which they receive interest. Hence, a higher interest rate spread is likely to be beneficial to banks. This effect is to be more significant when tested on the NIM subcomponent of revenues. *Loan growth* is linked to the traditional sources of revenue for banks, which stem from credit distribution. It is expected to positively impact not only net interest income, but also fees related to credit. *Stock market returns* are directly related to revenues derived from trading income. They are also strongly correlated with GDP growth, which makes it difficult to use as a proxy for overall banking profitability; even more so since GDP growth is jointly considered. Stock market volatility, which may increase banks' trading opportunities, yields higher non-interest income and profitability, but also increases provisions because of higher uncertainty, which 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 the countries where international groups may own assets. Nevertheless, it seems reasonable, first as French GDP growth does not prove, on average, uncorrelated to that of countries where French banks might own assets, and second because the international merger and acquisitions of French banks took place only in the very recent years. Another more practical

reason behind this decision is that we can only observe the path of French GDP growth to perform stress tests and do not want to impend artificially on the effect of a recession on ROA (conservative assumption on stress tests).

- ▶ The "inflation" variable is defined as the year-on-year variation in the French consumer price index.
- ▶ The "yield curve" variable is the difference between the 10-year French Treasury bond rate and the 3-month Euribor (Pibor before 1999) rate.
- ▶ The "stock market index's return" (volatility) variable is measured as the year-on-year growth of the SBF250 index's return (the annual historical volatility of the SBF250 index).
- ▶ The loan growth is the year-on-year relative change in the total credit volume in the French economy.

Figure 2 shows the developments in some of the main macroeconomic variables (GDP growth the yield curve) used in our model.

### Model

Our objective is to identify the macroeconomic, financial, and bank-specific determinant of banks' profitability. For this purpose, as shown in Figure 2, bank profits seem to persist over time. Hence, following Berger et al. (2000), we allow for the existence of an autoregressive component of RoA. More specifically, we consider a dynamic model specification including a lagged endogenous variable, to account for persistence. The model is written, for each date  $t$ , as:

$$\pi_{i,t} = c + \varphi_1 \pi_{i,t-1} + \sum_j \beta^j X_t^j + \sum_k \theta^k Z_{i,t}^k + \varepsilon_{i,t} \quad (1)$$

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

### Econometric investigation

Our econometric investigation is performed in four steps. As a first step, 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 Table 1 and tend to confirm the stationarity of the panel.

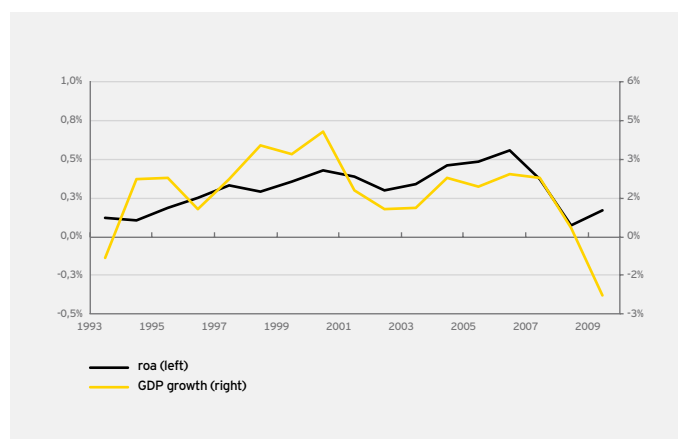


Figure 2: Evolution of GDP growth and yield curve (1993-2009)

The stationarity of the macroeconomic variables is also tested using a Dickey Fuller test but is not that relevant given the small number of observations (17 for each variable).

As a second step, 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 ratio and the share of non-interest income in total assets. Following Athanasoglou et al. (2008), we run model (1) with these variables as strictly exogenous, strictly endogenous, or one exogenous and the other endogenous. The Sargan tests, though they indicate that both could be considered as endogenous, appear in favor of considering  $nnii$ , i.e., the share of income coming from non-interest activities as endogenous and capital as exogenous. This may seem surprising as the equity ratio, as a target variable, is generally considered endogenous in most papers [Athanasoglou et al. (2008)].

A third question that may arise is the treatment of mergers and acquisitions (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 are two reasons for this: first, including a dummy variable for each merger may limit dramatically the number of degrees of freedom of the system;

Variables	Levin, Lin and chu		Fisher test	
	W-stat	p-stat	$\chi^2$	p-stat
RoA	-13	0.00	448	0.00
Capital	-167	0.00	487	0.00
Risk	-593	0.00	690	0.00
NNII	-19	0.00	494	0.00

**Results of the stationarity tests for the macroeconomic and financial variables**

Variables	Dickey-Fuller ERS		
	T-stat	1% critical value	10% critical value
GDP growth	-1.21	-2.73	-1.60
Spread	-1.81	-2.73	-1.60
Loan growth	-1.39	-2.73	-1.60
Inflation	-1.82	-2.73	-1.60
SBF return	-3.22	-2.73	-1.60
SBF volatility	-1.62	-2.73	-1.60

**Table 1: Results of the stationarity tests for the bank-specific variables**

second, as argued by Athanasoglou et al. (2008), the capital variable already accounts indirectly for potential M&A effects.<sup>3</sup>

Fourth, with regards to 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. We use two types of instruments for our difference equation: all exogenous variables (X and Z) as additional standard instruments except non-interest income (*nii*)<sup>4</sup> and lagged endogenous variables ( $\pi$  and *nii*) as difference GMM-type instruments. The difference equation used in our model is:

$$\Delta\pi_{i,t} = \varphi_1 \Delta\pi_{i,t-1} + \sum_j \beta^j \Delta X_t^j + \sum_k \theta^k \Delta Z_{i,t}^k + \epsilon_{i,t} \quad (2)$$

## Results

### 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, as identified in the literature: GDP growth, spread, inflation rate, stock market return, stock market volatility, loan growth, share of non-interest income, capital, expenditures, risk, and the constant.

<sup>3</sup> To check for robustness, we re-run our regressions excluding observations corresponding to a yearly increase in assets by more than 20%. This leaves the results unchanged.

<sup>4</sup> 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 an endogenous variable.

Firstly, we chose the stock market index's return as the measure of market activity. 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 the 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 -0.60 during the studied period. For that reason, in the remainder of the paper, we only consider stock market volatility as a proxy for market risk.

Regarding the other macroeconomic variables, we find that the inflation rate is not significant when combined with GDP growth. This may result from the strong relationship between these two variables. Loan growth is never significant and has been dropped from the remaining equations. Furthermore, among the banking specific variables, we find that the variables "risk" and "expenditures" are not significant but keep the former in the remaining results to be consistent with the underlying theoretical models.

Table 2 presents the final results, which are those that we will consider for the remainder of the paper as the main equation results.

The significant coefficient on the lagged endogenous variable confirms the dynamic specification. The coefficient of the lagged RoA, which equals to 0.171, 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 banking industry is fairly competitive (high speed of adjustment) or that informational opacity is low [Berger et al. (2000)].

The regression results confirm our prediction that a higher GDP growth, steeper yield curve, or higher inflation rate increase banks' profitability. The coefficient on GDP growth means that an increase in GDP growth by 1% increases the overall RoA of the whole French banking system by about 0.04%, which is quite important 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 lower profits. To test whether the relationship is still relevant when economic growth slows down,

Arellano-Bond dynamic panel data estimation (t = 1993-2009)						
Number of Obs. = 2292						
Number of groups = 370						
ROA	coefficient	p	coefficient	p	coefficient	p
Lag1 (Roa)	0.171**	0.034	0.173**	0.035	0.171**	0.041
GDP growth	0.039***	0.001	0.043***	0.000	0.041***	0.000
CPI	-0.015	0.334				
Spread	0.047***	0.002	0.057***	0.000	0.056***	0.000
L1. SBF volatility	-0.00004**	0.044	-0.00003*	0.064	-0.00004*	0.058
Small	0.002	0.182				
Large	-0.001*	0.084				
Capital	0.013***	0.003	0.013***	0.003	0.013***	0.003
NNII	0.065**	0.019	0.065**	0.020	0.065**	0.020
Risk	-0.002	0.311				
Market power	0.031	0.617				
Low-growth* GDP					-0.002	0.849
Wald test	chi2(11) = 74	p>chi2 = 0.00	chi2(6) = 51	p>chi2 = 0.00	chi2(7) = 64	p>chi2 = 0.00
Sargan test of over-identifying inst.	chi2(238) = 225	p>chi2 = 0.71	chi2(238) = 223	p>chi2 = 0.70	chi2(238) = 226	p>chi2 = 0.70
Autocorrelation test AR(1)	z = -3.02	p>z = 0.00	z = -3.02	p>z = 0.00	z = -3.01	p>z = 0.00
Autocorrelation test AR(2)	z = 0.26	p>z = 0.80	z = 0.24	p>z = 0.81	z = 0.24	p>z = 0.81
Overall R <sup>2</sup>		45%		39%		38%
Between R <sup>2</sup>		61%		52%		51%
Within R <sup>2</sup>		18%		17%		16%

Table 2: Results for the main equations

we re-run the main equation with a cross-variable which equals the economic growth times a time dummy for periods when economic growth is lower than 2%. The results remain unchanged.

With regards to the effects of banking structure on banking 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 positive effects. The fact that 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, consistent with descriptive statistics and the empirical literature.

#### Back testing of the results

In order to test the reliability of our model, the following standard tests for linear dynamic panel models are presented in the result table of each regression: the Wald-test indicates significance 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 models; and the second-order autocorrelation test on errors have been rejected so that there is no autocorrelation of order 2 of differenced errors.

#### Additional robustness checks

##### Baseline equation re-estimated with group-effects

As shown in Table A1, the panel used may exhibit slight differences in the behavior of sub-samples of the panel. In this subsection, we re-estimate the main equation with specific effects linked to the legal status or to the size of the individuals.

##### Individual effects linked to banks' legal status

We estimate a further regression for RoA where the variable GDP growth has been substituted by GDP growth times indicators ( $X^1 I_{it}$ ), which are dummy variables on banks' legal status. The aim is to test the differentiated effects of banks' legal statuses in events of macroeconomic shocks.

Arellano-Bond dynamic panel data estimation						
(t = 1993-2009); Number of Obs. = 2292; Number of groups = 370			(t = 2000-2009); Number of Obs. = 1358; Number of groups = 246			
ROA	Coefficient	p	Coefficient	p	Coefficient	p
Lag1 (L.Roa)	0.169**	0.021	0.176**	0.015	0.120*	0.075
GDP growth					0.035**	0.021
Spread	0.066***	0.000	0.060***	0.000	0.082***	0.000
L1. SBF volatility	-0.00005***	0.008	-0.00004**	0.043	-0.00007***	0.002
Capital	0.013***	0.002	0.013***	0.002	0.012***	0.005
NNII	0.066**	0.024	0.066**	0.026	0.061**	0.024
Bank*GDP	0.052***	0.010				
Cm*GDP	0.010	0.318				
IF*GDP	0.104***	0.000				
Large*GDP			0.034**	0.014		
Average*GDP			0.037***	0.006		
Small*GDP			0.087**	0.024		
Wald test	chi2(8) = 58	p>chi2 = 0.00	chi2(8) = 59	p>chi2 = 0.00	chi2(6) = 64	p>chi2 = 0.00
Sargan test of over-identifying inst.	chi2(238) = 235	p>chi2 = 0.54	chi2(238) = 223	p>chi2 = 0.74	chi2(208) = 193	p>chi2 = 0.74
Autocorrelation test AR(1)	z = -3.10	p>z = 0.00	z = -3.08	p>z = 0.00	z = -3.35	p>z = 0.00
Autocorrelation test AR(2)	z = 0.26	p>z = 0.80	z = 0.26	p>z = 0.80	z = -0.68	p>z = 0.49
Overall R <sup>2</sup>		44%		43%		32%
Between R <sup>2</sup>		58%		57%		42%
Within R <sup>2</sup>		19%		18%		14%

**Table 3: Results for the equations with individual effects**

$$\pi_{i,t} = \varphi_1 \pi_{i,t-1} + \sum_l \beta^l x_t^l + \sum_k \theta^k z_{i,t}^k + \sum_q \delta_q \text{GDP}_t + I_q + \varepsilon_{i,t} \quad (3)$$

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

Table 3 presents the results for this alternative estimation. Our main findings are that mutual and cooperative banks appear less impacted by GDP growth shocks than commercial banks, with a sensitivity of 0.01 against 0.052.

#### Individual effects linked to 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 is that small banks seem to be more affected than other banks by shocks on GDP growth. All in all, the results can be summarized as follows: we do not find a clear homogeneity of the panel with regards to 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.

#### 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 2000-2009. A reason for choosing this restricted period is that some authors find that ROA's reaction to macroeconomic variables are somewhat different in the post-1999 period. This is due to the introduction of the euro; a different business model of banks; and a growing influence of securitization, that would threaten the old model of profits through maturity transformation, and thus alter the sensitivity of ROA to spread fluctuations.

In addition, despite the fact that the gap is in general small, we find that the model, as estimated over the whole period, systematically overestimates the actual RoA from 1994 to 1999, as it is the opposite in the remaining period. Results of the main

model re-estimated over the 2000-2009 sub-period presented in the last column of Table 3 clearly support 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, only the magnitude of the various coefficients matters. In addition, changing the coefficients with those re-estimated over the 2000-2009 sub-period leaves the gap between estimated and actual ROA unchanged (chart available upon request).

#### **Orthogonalizing the macroeconomic variables**

As our three variables of interest (GDP growth, interest rate spread, stock market volatility) prove somewhat correlated, we re-estimate the main model after orthogonalization of those variables. For this purpose, we keep our GDP growth variable unchanged. We regress the spread on the GDP growth and a constant term and define the orthogonalized spread\* as the residuals of this equation. Moreover, we regress the volatility of the stock market on the GDP growth, the spread, and a constant term and define the residuals of that equation as the new stock market volatility. We re-run all the equations above using those new variables. We find that, on the whole, our main results are robust.

#### **Using an alternative measure of product diversification**

As our measure of product diversification 'nnii' is by construction an element of the RoA and might appear very specific to financial and investment firms (for which it exhibits the highest values), we estimate an alternative model which relies on another measure of product diversification, that is to say the ratio of loans to the total assets, as proxy for the loan activity of banks. When we re-run the Sargan test, we find that our new variable loans/assets has to be specified as an exogenous variable, whereas the ratio of capital now appears endogenous and is specified as such in the regression. Our findings are fully consistent with the main results of Table 2.

#### **Macroeconomic stress-tests of French banks' profitability**

Stress-tests focused on banking profitability seek to identify the most important economic and financial channels of contagion of an initial shock that may affect the stability of the banking sector. Indeed, as the previous section showed, the economic and financial 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.

#### **The stress-testing framework**

The approaches by Lehmann and Manz (2006) and Rouabah (2006), focusing on Switzerland and Luxemburg respectively, conclude that the impact of macroeconomic and financial shocks on banks' profits is relatively modest, demonstrating that the two banking sectors are resilient. But the analysis carried out in these papers, albeit interesting, is limited to sensitivity analysis and does not consider the effect of a comprehensive adverse scenario on banking variables, especially profitability.

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 [Baghli et al. (2005)] forecast models (*Mascotte* and *Nigem*). This means that we simulate the effects of various exogenous shocks (in our stress test exercise, demand shocks yielding recession scenarios, a yield curve flattening, and an exchange rate shock), conditionally on these models, on the "stressed" output variables of the macroeconomic model (that prove to be our "stressed" explanatory variables for the banking model), which are then used as "stressed" inputs in our revenue model. Hence, we get "stressed" profitability, which is compared to the value obtained without any stress (i.e., in line with the basis line of the 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 a feature of traditional macroeconometric models. 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 analyzing financial relationships and how different agents in the system may be financially constrained. Hence, in such models, there is no limit to credit demand from households. Another limitation is related to the fact that our model does not aim to take into account "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 ceteris paribus: 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 in net interest revenues. For these 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 results.

### Results of the stress-test

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 the baseline scenario. In April 2009, we designed and tested five hypothetical stress-scenarios which were all found at the time to be consistent with the definition of stress-test scenarios (severe but plausible), though their probability of occurrence is from a statistical and historical point of view likely to be different. It is important to note that the design of stress-scenarios rely strongly on expert judgment. It should also be noted that our goal is not to quantitatively compare the magnitude of the effects of each adverse scenario on others. We are much more interested in the qualitative comparison of different outputs of various scenarios and the absolute magnitude of the effects of scenarios over a certain threshold, for instance, negative profitability of banks. Hence, the five scenarios that were worth simulating were as follows:

- ▶ 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 3-month and -400 bp OAT (government bonds) 10-year].

In order to determine whether the recession shocks tested, though they appear 'severe' enough, were plausible, we also studied the distribution of GDP growth in France from 1875 to 2008, excluding the war years, in order to calibrate the probability of recession. The results of the non-autocorrelation tests demonstrated that GDP growth is a White Noise process. Moreover, GDP growth does not follow a normal distribution according to the normality tests. Thanks to the distribution of GDP growth, we simulate the probability of the three recession scenarios defined previously.

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 U.S.D/EUR	-0.6	0.0
5	Flattening of the yield curve	0.0	0.4

**Table 4: Design of scenarios**

	RoA	-1% GDP growth	-2% GDP growth	-3% GDP growth	-25% depreciation of U.S.D/EUR	Flattening of the yield curve (-200bp ST, -400bp LT)
Aggregated data	T+1	0.04%	-0.01%	-0.03%	0.05%	0.07%
	T+2	0.01%	-0.03%	-0.07%	0.10%	0.11%
Cooperative banks	T+1	0.09%	0.08%	0.08%	0.10%	0.10%
	T+2	0.07%	0.06%	0.05%	0.09%	0.09%
Commercial banks	T+1	0.05%	-0.01%	-0.04%	0.06%	0.09%
	T+2	0.03%	-0.03%	-0.08%	0.14%	0.16%
Financial firms	T+1	0.00%	-0.13%	-0.19%	0.02%	0.08%
	T+2	-0.03%	-0.14%	-0.25%	0.19%	0.23%

**Table 5: Results of stress-tests using the main equation results**

According to this distribution, the average value of GDP growth is 2.7% and the cumulative probability associated with it is about 58%. Hence, the probability that the GDP growth is greater than the average value is equal to 42%. We find that the probability of GDP growth being smaller than -1% is 14%, 2% is 8% and -3% is 5%.

As stated earlier, 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 the Banque de France Mascotte model [Baghli et al. (2005)] and NIGEM, with the latter being provided by the NIESR (National Institute of Economic and Social Research) and used to introduce international interactions.

Table 4 presents the effects of these scenarios on the variables used as inputs in our profitability models. Table 5 presents the results of stress tests using the baseline model presented in table 2. Our results demonstrate that the French banking system is resilient to the set of comprehensive adverse scenarios tested. Only the severe recession scenarios (-2% growth and -3% growth) would generate negative profits. On the contrary, other



scenarios (flattening of the yield curve, exchange rate shock, and moderate recession) would yield positive profits. In comparison with the actual figures for the French banking system recorded in 2009, our results are consistent with the reporting of banks. Indeed, as the GDP growth forecast for 2009 is likely to be in the range [-2.4%; -2%] (see for instance recent OECD's and IMF's outlooks), our -2% stress scenario constitutes a good benchmark. The annual RoA of -0.01% forecasted by the model is not that far from the actual figure, which equals 0.02% for the French banking industry in aggregated consolidated data. 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 relatively to the mean of RoA over the sample (0.67%). This reveals the robustness of our model as a backtesting check. 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, providing, again, support of the robustness of our model.

In order to answer the question of why French banks and the French banking system as a whole proved that resistant to strong economic shocks, we would need to dig deeper and analyze income subcomponents [Coffinet et al. (2009)], something which is beyond the scope of this article. Nevertheless, the interpretation of the main equation's results can provide some intuition. Indeed, one of the three main macroeconomic drivers – the interest rate maturity spread – is clearly linked to the traditional maturity transformation activity of banks. GDP growth could also be associated to that income subcomponent as stronger economic growth could enhance the credit demand and hence support the loan activity and profitability of banks. Another significant driver of overall banks' profitability – stock market volatility – is clearly specific to trading revenues (and indirectly GDP growth). As a result, a conclusion that can be drawn from these results is that the French model of universal banking – that is to say the diversification of products and revenues by banks – could lead to opposite developments in income subcomponents in depressed situations. The higher risk and lower profits generated by trading activities and economic downturn being compensated by a more profitable traditional credit activity, driven by a widening of the yield curve in downturns – e.g., due to interest rate cuts by the central bank. Consequently, our results can be viewed as a support for the model of universal banking as a source of resilience.

### **Conclusion**

Our results provide evidence of statistically significant relationships between the macro environment and the profitability of the banking industry. In particular, we provide strong evidence that the overall French banking system's profitability positively depends on the French GDP growth, the stock market return, the interest rate maturity spread, the share of non-interest income, and the capital owned by banks, and negatively on the bank's size and credit risk. These results are consistent with those obtained in the banking 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 well in forecasting the good results of the French banks in spite of the current depressed environment. These results could be interpreted as a vindication for the model of universal banking, though further work should be carried out to arrive at definite conclusions in that regard.

However, a lot of work remains to be done, as other risk channels may affect banks' profits but are not simulated in our 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, etc.). Moreover, the model may be refined in terms of econometrics, as it fails to explicitly account for nonlinearities that may arise in extreme events. Since we are especially interested in the extreme losses arising from stressed-scenarios, it would be of particular interest to implement quantile regressions.



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## Stress-testing banks' profitability: the case of French banks

1993-2009	All banks	Commercial banks	Mutual and cooperative banks	Financial and investment firms	Large banks	Average banks	Small banks
<b>RoA</b>							
Average	0.7%	0.5%	0.6%	0.9%	0.4%	0.7%	0.9%
Std.	0.7%	0.7%	0.3%	1.0%	0.4%	0.7%	1.0%
Min	-1.6%	-1.6%	-0.7%	-1.5%	-1.5%	-1.6%	-1.6%
Max	4.1%	4.1%	3.2%	4.1%	3.0%	4.1%	4.1%
Obs.	2896	920	1070	906	724	1448	724
<b>Capital/assets</b>							
Average	10%	8%	8%	14%	6%	9%	17%
Std.	12%	13%	4%	15%	4%	7%	19%
Min	-3%	0%	-3%	0%	0%	-3%	0%
Max	100%	100%	31%	97%	23%	81%	100%
<b>Non-interest income/assets</b>							
Average	3%	2%	2%	4%	1%	2%	5%
Std.	9%	4%	1%	15%	1%	3%	16%
Min	-16%	-16%	0%	-3%	0%	-16%	-3%
Max	210%	33%	7%	210%	7%	68%	210%
<b>Expenditures/assets</b>							
Average	3%	3%	2%	5%	2%	3%	6%
Std.	8%	3%	1%	14%	1%	2%	15%
Min	0%	0%	0%	0%	0%	0%	0%
Max	195%	30%	6%	195%	6%	59%	195%
<b>Individual net operating income/total operating income</b>							
Average	0.6%	1.1%	0.4%	0.2%	2%	0.2%	0.0%
Std.	1.9%	3.1%	1.1%	0.8%	4%	0.1%	0.0%
Min	0%	0%	0%	0%	0%	-0.2%	0.0%
Max	23%	23%	11%	12%	23%	1.3%	0.4%
<b>Loans/assets</b>							
Average	74%	72%	84%	66%	73%	77%	72%
Std.	24%	21%	9%	32%	16%	23%	29%
Min	0%	4%	40%	0%	3%	0%	0%
Max	100%	99%	96%	100%	98%	99%	100%
<b>Loan loss provisions/loans</b>							
Average	3%	3%	1%	5%	1%	2%	7%
Std.	10%	12%	5%	12%	2%	8%	16%
Min	0%	0%	0%	0%	0%	0%	0%
Max	100%	100%	96%	99%	21%	99%	100%
<b>Ln (Assets)</b>							
Average	15	15	16	14	17.5	15	12
Std.	2	2	1.1	2.1	1.3	0.7	0.9
Min	7	10	12	7	16	14	7
Max	22	22	21	21	22	16	14

Table A1: Descriptive statistics of RoA

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