Predicting the Risk of Bank Deterioration: A Case Study of the Economic and Monetary Community of Central Africa

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1. Background to the study

Preventing the risk of bank distress is a fundamental concern for political decision-makers and bank supervisory authorities in view of the important role that banks play in the economic system. Indeed, banking institutions play the role of financial intermediaries and enable a better allocation of financial resources that are indispensable to the economy. At the same time, they provide financial services to their customers, such as money transfers, advice, and manual exchange. In many developing countries where the financial system is still in its infancy (high debt economies), the banks are one of the main source of funding for the economy. Hence, the necessity for such countries to have solid banking institutions capable of providing sound and sustainable funding for economic activities.

However, economic history is riddled with banking crises that remind us of the vulnerability of banking institutions. In the last three decades, numerous crises have hit both developed and emerging countries. For instance, in the USA, 1,500 commercial banks and 1,200 savings banks went bankrupt between 1984 and 1995 (Caprio et al., 1998). In Japan, bad debts have crippled the banking sector. In France (in 1992) and in Great Britain (in 1988 and 1993), big financial institutions experienced great difficulties. More recently, the financial crises in Asia (in 1997), and in Brazil, Mexico and Russia (in 1998) were also characterized by the bankruptcy of a number of banks. Sub-Saharan Africa has not been spared such banking failures. Here are some examples: Nigeria, for instance, has experienced banking failures since the 1950s (Sobodu et al., 1995). South Africa experienced two major banking crises, in 1977 and 1989. Ghana was hit by systemic crises from 1982 to 1989 and non-systemic ones between 1995 and 2003. The member states of the West African Economic and Monetary Union (UEMOA) have experienced similar banking crises since the mid-1980s. At the end of 1988, more than 30 banking failures had been recorded. Added to this number are 25 financial non-banking establishments that were liquidated during the 1980–1993 period in the entire UEMOA (Powo Fosso, 2002).

Within the Economic and Monetary Community of Central Africa (CEMAC), which encompasses Cameroon, the Central African Republic, Congo-Brazzaville, Gabon, Equatorial Guinea and Chad, the first banking crisis occurred in the mid-1980s and could be brought under control only in the 2000s. The figures from the Bank of the Central African States (BEAC) show that 11 of the banks that were operational in these states in the 1990s were either under liquidation or had been shut down, while four banks were in a critical situation, that is, in quasi-bankruptcy. While this first wave of banking crises hit all the countries in the region, the severity of the crises varied between countries: in Cameroon, four banks went into liquidation or were closed, while two banks were in a critical situation; in the Central African Republic, Chad and Equatorial Guinea, two banks in each country went into liquidation; and one bank went into liquidation in Gabon, while one bank was in a critical situation in Congo-Brazzaville.

All those banking crises were associated with macroeconomic, financial and institutional factors. Indeed, a decline in the GDP growth rate, real interest rates that were excessively high, and abnormal inflation rates are all macroeconomic factors that could help explain why those banking crises happened. However, the systemic crises in the banking sector cannot be explained by the weaknesses of the macroeconomic environment. Therefore, following Calvo, Leiderman and Reinhart (1994), it is important to take into account the structural characteristics of the banking sector. Inappropriate investments and the accumulation of bad debts also contributed to making the banks vulnerable and thus aggravated the crises. The absence or inadequacy of real bank supervision based on clear and well-understood rules left banking institutions to moderate themselves, which left them largely unconcerned about the impact of their decisions on solvency. It is against the backdrop of those unfortunate experiences and, especially, of the excessively high costs on the whole economy that arose from the banking crises in all those countries that the governments tried to seek solutions. In this respect, they consolidated the macroeconomic environment and strengthened the legal framework for banking supervision. Banking supervision is based on internationally-recognized good practices; here we are referring specifically to the core principles for effective banking supervision set up by the Basel Committee (Basel Committee on Banking Supervision, 1997 & 2006).

In the CEMAC area, governments were confronted with a serious economic and banking crisis at the end of the 1980s. After an euphoric spell generated by the high prices of export commodities, notably oil, the economies of those countries were shaken by external shocks resulting from the sudden fall in oil prices, which compromised economic growth. According to the BEAC (1988), the growth rates of the real GDP in constant francs reached negative levels, which meant a recession. Countries in the region accumulated budget deficits as high as 9% of GDP. Current external balances that were marked by structural deficits worsened, while at the same time public external debt rates reached 100% levels from 1993, and exchange reserves dried up following the collapse in export revenues. Unable to pay their debts, the CEMAC countries accumulated payment arrears owed to both domestic and external creditors. At the same time, domestic deficiencies related to the prevailing hard economic situation in the area gradually drove the banking system into a worrying situation (see annexures A1 and A2). Errors in management, which were characterized by a lack of control of overhead expenses and an often lax policy of granting loans to customers, led to a situation of high levels of outstanding debts, and those debts were bad debts.[1] The difficulties of the banking sector in the CEMAC countries continued beyond the 1990s when most of

1 See "BEAC: Évaluation des programmes d'ajustement financier : cas des pays de la Zone BEAC dans l'Afrique centrale et les programmes d'ajustement ". [BEAC: Evaluation of financial adjustment programmes: the case of countries in the BEAC area in Central Africa.] Seminar organized by the Bank of Central African States (BEAC) in Yaoundé from 20 to 22 July 1988.

the banks had become insolvent, run out of liquidity and were making no profit at all; in other words, when they were in quasi-bankruptcy. A survey conducted by COBAC (see Madji, 1997) confirmed that more than 90% of the bankruptcies during that decade were linked to bad management, which was related to a mismatch between resources and jobs. This bad management was coupled with generalized practices of cooking the books and falsifying accounts, interference from governments on how to manage and to direct the credit allocation policy, the legal environment that was not conducive to obtaining guarantees, and a lax supervisory framework.

As part of the financial programmes, which governments in the area were required to submit, measures were taken to eradicate those banking crises. A reform of the banking supervision system and a restructuring programme were undertaken. As part of these measures, the Banking Commission of Central Africa (COBAC) was created in October 1990. It was assigned supranational authority in the administrative, jurisdictional, regulatory and supervisory areas. Its principal mission was to ensure banking supervision in all the member states of CEMAC.[2]

So, for more than ten years, the banking sector in the CEMAC countries has been the subject of close supervision by COBAC with the aim to protect depositors and prevent similar bankruptcies to those that occurred in the 1990s for which society as a whole had to pay such a high price (among others depositors, shareholders, the Treasury, employees and businesses).

In order to detect early which banks are experiencing difficulty and to launch prompt corrective measures, COBAC, like other banking supervision authorities in the rest of the world, uses two types of supervision: an on-site examination and a permanent examination, also known as off-site examination. The former consists of deploying inspectors to banks to assess their financial health, while the latter examination is carried out from the COBAC offices on the basis of regulatory financial statements sent to the commission every month by the credit establishments.

While at the outset the permanent examination of credit establishments was limited to only the regulatory ratios, since 2000 this examination has been widened to include, among other things, the financial and prudential analysis of the credit establishments that send the regulatory financial statements in the form of electronic files to the commission through a "System for the Collection, Use, and Release of Regulatory Statements to Banks and Financial Establishments", or CERBER (for Collecte, Exploitation et Restitution aux Banques et Établissements financiers des États Réglementaires). This system ensures an

2 It should be borne in mind that although the CEMAC member states had a common central bank and a common currency, bank supervision was until then partially undertaken by the member states themselves. Although this bank supervision seemed unified because of the prudential rules that largely seemed homogeneous from one member state to another, the BEAC did not play any central role except with regard to the currency. With regard to bank supervision, the ultimate responsibility was solely on those member states that had not been able to take appropriate measures in time against the failing banks. The effects of all those deficiencies were exacerbated by the fall in the prices of basic commodities at the world level, which degraded the solvency of the banks' main clients operating in the commodity export industry. This situation, in turn, fostered the accumulation of bad debts whose weight in many cases reached more than 50% of portfolios. It is against this backdrop of the sudden fall in the prices of raw materials that the governments in the region were forced to become concerned about cleaning up not only the macroeconomic environment but also the banking situation.

automated analysis of regulatory statements and extracts from the lending institutions' financial structure equilibrium, their prudential ratios, and their rating as summarized in the Lending Institutions Rating System, known as SYSCO (for Système de Cotation des Etablissements de Crédit). The SYSCO rating system is an adapted version of the CAMEL[3] procedure, which initially encompassed five factors: capital adequacy (C), asset quality (A), management quality (M), earnings ability (E), and liquidity position (L). However, with the development of financial markets, a sixth factor was added: sensitivity to market risk (S). The SYSCO system was modelled on CAMELS. That is, it takes into account the adequacy of share capital, the quality of the credit portfolio, the management and internal audit system, profitability and the liquidity position.

Based on data from CERBER, the SYSCO rating is assessed every month according to specific components, as set out in Table 1.

Table 1: Weightings of the SYSCO variables

Component	Variable	Weighting	Total
Adequacy of share capital (C)	Creditworthiness Risk diversification Minimum capital Insider lending Shareholding Fixed assets	[-10, +10] [-6, +6] [-2, +2] [-4, +4] [-2, +2] [-6, +6]	[-30, +30]
Asset quality (A)	Bad debts Provisions	[-10, +10] [-10, +10]	[-20, +20]
Management (M)	Management and internal audit	[-20, +20]	[-20, +20]
Earnings (E)	Operating coefficient Windfall profits	[-8, +8] [-2, +2]	[-10, +10]
Liquidity (L)	Liquidity Transformation	[-15, +15] [-5, +5]	[-20, +20]

Sources: COBAC, Bulletin N°4, (2001) and reclassification by the authors

The scoring method was used to allocate points to each component. The overall score varies between -100 and +100. The various components were weighted on the basis of the experience the supervisors had of the trends in each aspect of the component. For each credit establishment, a score is thus automatically generated and, based on the value of this score, the establishment is classified into one of the following eight categories.

3 This acronym designates the six criteria used while rating banks, namely: capital adequacy, asset quality, management quality, earnings ability, liquidity position, and sensitivity to market risk.

Table 2: The SYSCO scores

Rating	Description	Level of the score
1	Solid financial situation	69.8 to 100
2	Good financial situation	39.1 to 69.7
3A	Slightly vulnerable financial situation	34.2 to 39.0
3B	Averagely vulnerable financial situation	8.8 to 34.3
3C	Very vulnerable financial situation	-6.0 to 8.7
4A	Critical financial situation	-16.6 to -6.1
4B	Very critical financial	-56.4 to -16.7
4C	Irremediable financial situation	-100 to -56.4

Source: COBAC,Bulletin N°4 (2001) and reclassification by the authors

By classifying the credit establishment into one of the eight categories, COBAC forms an idea of the establishment's financial solidity or vulnerability. The establishments classified as Categories 1 and 2 are deemed to be solid, while those in the other categories are deemed to be vulnerable.

A credit rating system is most often characterized by its transition matrix[4]. Thus, the annual transition matrix with multiple states estimated over the period under study, given in Table 3, illustrates the different transitions from one category into another. Indeed, the estimation is based on the very strong assumption that the evolution in the rating of a bank is a Markov chain. Over the period under study, the matrix of the estimated probabilities shows that there exists an 58.8% chance of having banks that are rated as belonging to Category 1 and 81.6% chance of them belonging to Category 2. It can be observed in the first line that there is a 41.2% probability of having banks that move from Category 1 into Category 2. And if there is an 81.6% chance of having banks that stabilize in category 2, there is a 6% probability of getting those that move into category 1, a 4.8% probability of having those that move into category 3A, a 5.4% probability of having those that move into 3B, and a 1.2% probability of having those that move into 3C.

4 It is a transition matrix with multiple states. If we use *s(t)* to designate the state of the bank at a given date t, the cell i, j of the table represents the probability of changing from status i to status j at a given time in the future h: $Pr\ (s(t) = i, s\ (t + h\ ) = j)$

Table 3: Probabilities of annual transition with all states

	1	2	3A	3B	3C	4A	4B	Total
1	58.8	41.2	0.0	0.0	0.0	0.0	0.0	100.0
2	6.6	81.6	4.8	5.4	1.2	0.6	0.0	100.0
3A	0.0	50.0	12.5	25.0	0.0	12.5	0.0	100.0
3B	0.0	46.7	4.4	31.1	4.4	4.4	8.9	100.0
3C	0.0	20.0	0.0	70.0	10.0	0.0	0.0	100.0
4A	0.0	27.3	0.0	9.1	27.3	9.1	27.3	100.0
4B	0.0	0.0	6.7	6.7	6.7	26.7	53.3	100.0
Total	7.5	63.1	4.6	12.8	3.2	3.6	5.3	100.0

Source: Authors' estimations based on COBAC CERBER data (from 2001 to 2007)

We further estimated the matrix of transition probabilities with two states (with states 1 and 2 representing a solid financial situation and the others representing a vulnerable situation). The matrix is presented in Table 4[5].

Table 4: Probabilities of annual transition with two states

Banks	Solid situation	Vulnerable situation	Total
In a solid financial situation	89.6	10.4	100.0
In a vulnerable situation	33.3	66.7	100.0
Total	69.9	30.1	100.0

Source: Authors' estimations based on COBAC CERBER data (from 2001 to 2007)

Over the period under study, the matrix of the estimated probabilities shows that about 10% of the banks that were rated to be in a solid financial situation experienced a deterioration after one year, while 30% of banks rated as vulnerable saw their situation improve at the end of the same year.

It should be noted that the transition matrix with seven states brings to light high instability in relation to the evolution of the situation of banks. But this instability does not seem to be real when one considers the two-state matrix. This means that it has to do with the SYSCO tool's inadequate calibration.

5 It should be noted that the estimator, using the maximum likelihood method, of the probability of transition from state i to state j is given by the following formula: $P_{ij}(t,t+1) = \frac{N_{ij}(t, t+1)}{n_i(t)}$

Indeed, under the current version of SYSCO, the solid banks are those whose score is higher than 39.2, while the vulnerable banks are those whose score is below this. Yet, from this threshold of 39.2, the SYSCO tool is less discriminating. This very threshold gives SYSCO an asymmetrical look. In relation to this, expert advice (see the report by Thoraval, 2008) tells us that the excessive weighting of Category 2 reveals marked discrimination on the part of the SYSCO tool, whose main weaknesses include questionable weighting coefficients and too simple or linear determination thresholds or filters, all of which render the tool less effective. It is noted that the filters used have been constructed based on the regulatory level, which is a minimum, and not on the average observed in the sub-region, which is often quite different. For instance, concerning the ratio of risk cover, the threshold has been fixed at 8% while, in practice, the average of this ratio in the sub-region over the 2000-2008 period varied from 12 to 13%. The same deficiencies can be observed in the other financial variables that make up the SYSCO system. As a result, the threshold never functions properly because the aim of a credit rating system is to distinguish between banks that are doing well and those that are failing. Besides, the threshold must be fixed at a level close to the average for it to have discriminating power. To the extent that the goal of a credit rating system is to be able to discriminate between banks quality-wise in view of future action, the results of the current SYSCO system could not be used to construct an effective early warning system model capable of predicting which banks would be failing at a given time in the future.

2. Statement of the problem and objectives of the study

Statement of the problem

The creation of the SYSCO tool has certainly made it possible to produce a typology of banks according to their risk profile, which in turn would enable the supervisory authority to better orient its action. Nevertheless, since the tool enables such a typology on the basis of bank performance that has already taken place, it did not enable the supervisory body to anticipate the deteriorating situation that the banks in the sub-region[6] faced due to, among other reasons, the deficiencies in its design. All that the supervisory body could do was to watch the situation unfold. This is because SYSCO's results of the appraisal of the credit establishments' financial solidity, which report the risk of a largely deteriorated financial situation, are only available after the deterioration has already happened. This means that audit teams are sent to the credit establishment with too much delay, while in the meantime its financial situation may have been irremediably compromised. This is likely to detract from the efficiency and credibility of the supervisory organ.

Clearly, the question that arises here is whether the existence of an early warning system would have enabled the supervisory authority to anticipate the forms of bank distress that have been recorded within the CEMAC area in recent years. The answer to this question will come from constructing and testing an early warning model for the banks in this area. This in turn raises several specific questions: What type of model to choose in view of the nature of the data available and the methods existing in the literature? What explanatory factors to look for? And, finally, how can one represent the quality of the said model from data that were obtained before and after the survey?

It should be noted that the importance of the management system has been established as an explanatory factor of bank failures (Barr and Siems, 1996). Since the CEMAC area, like all the other regions in sub-Saharan Africa, is beset by numerous managerial and institutional deficiencies, the issue in this paper is how to represent the quality of bank management and the extent to which this quality explains the difficulties encountered by the bank concerned.

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6 Despite a definite improvement, the financial situation was still deemed to be fragile or critical (rating 3 or 4) for 17% of the lending institutions rated, against 35.5% in 2001 (COBAC: Rapport annuel, 2006).

Objectives and interest of the study

The aim of this study is to propose an early warning model capable of detecting or anticipating the risk of bank deterioration within the CEMAC area; a model that would incorporate, in addition to financial variables, a proxy management variable as well as economic circumstances, which would enable us to try to provide answers to different questions.

The objectives of the study are to:

1. Measure management quality by using the data envelopment analysis (dea) method;
2. Specify and identify an econometric model of banking deterioration by using financial variables, economic circumstances and the management proxies obtained from the dea; and
3. Represent the model's prediction quality on the basis of data obtained before and after the survey.

Beyond the issue of bank supervision, this study is also of interest from a scientific point of view because of its choice of modelling method. We chose to use the autoregressive logistic model, which will enable us to model state transitions, because, as we shall see in the methodology section, while using a discriminant analysis or classical logistic regression would allow us to highlight the factors that discriminate between solid and vulnerable banks, it would not be the appropriate way of modelling the transition of banks from one state to another over time.

The preceding two sections dealt with the background to the study, stated the problem and the objectives of the study. The remainder of the paper is as follows: Section 3 reviews the literature, Section 4 describes the methodology, Section 5 presents the results, Section 6 validates them, Section 7 presents simulations and proposes policies, while Section 8 concludes the paper.

3. Review of the literature

There is only a slight difference between the models that predict bank deterioration and those that predict bank failure. The first models of bank failure prediction were put forward in the USA from 1970 by Meyer and Pifer (1970). Their influence in the literature grew considerably from the early 1990s with the increase in cases of bank failure. However, most of the studies reported in this literature were essentially from the USA and focused on a bank typology based on the CAMEL(S) rating system in order to highlight the factors underlying bank failure. Several points of difference can be pointed out between those studies, though: first, at the methodological level, Sinkey (1975) and Altman et al. (1977) used discriminant analysis, while other contemporary authors used models of the logit type (Martin, 1977; Pantalone and Platt, 1987) and the probit type (Barr and Siems, 1996). The second difference lies in their choice of proxy variables for the components of the CAMEL(S) rating. For instance, Barr and Siems (1996) included in their model scores of technical efficiency that were derived from the non-parametric method of DEA so as to approximate the criterion of "management quality"; they also included a variable that represents local economic conditions, namely, the rate of growth of residential real estate. The third difference has to do with the period the different studies covered, the size of the sample used, and the period for detecting the telltale signs of bank failure.

In a detailed study, Martin (1977) analyzed a sample of 5,700 banks, 58 of which were failing over the 1970–1976 period. He proposed a logit model with, as explanatory factors, gross capital related to risky assets and a variable similar to the Cooke ratio implemented within the Basel framework to represent creditworthiness. This variable was found to be significant and to have a negative effect on the probability of bank failure. Martin represented profitability using return on assets (ROA), which too was found to have a negative effect on the probability of bank failure, while the ratio of gross amortization compared with the net bank income had a positive effect. The share of commercial and industrial loans in total liabilities contributes to rendering banks vulnerable, all else being equal.

Hanweck proposed, in 1977, a probit model estimated by using a sample of 209 banks, 29 of which were failing. In this case, the bank creditworthiness was approximated using the ratio of share capital to total assets. This variable can also be likened to the Cooke ratio, the only difference being that it is estimated in relation to the total balance sheet. It thus produces the ratio of loans to shareholders' equity. The two variables contribute to increasing the banking failure probability. Hanweck estimated ROA and, like Martin, he obtained a negative coefficient, as he also did for the variation of the net bank income related to the assets and to the variation in the total balance sheet. Pantalone and Platt (1987) carried out their study over the 1983-1984 period. They used a sample of 339 banks, 113 of which were failing. They found that the probability of bank failure was negative, as was ROA. The ratio of loans to the assets and commercial and industrial loans (compared to the total loans) appeared to be elements contributing to the vulnerability of banks, but economic circumstances were not found to be a relevant factor.

From a sample of 11,473 banks, among which 42 were failing, Estrella et al. (2000) constructed a model of bank failure. In this model, they only included variables that enabled them to measure the level of equity. These are variables related to ratios of equity to loans, to net income and to the total assets. Of these variables, only the ratio of equity to gross income was found to be significant and to contribute to the solidity of banks.

However, previous studies did not focus enough on the management quality as one of the explanatory factors for banking deficiency. The study by Barr and Siems (1996) bridged this gap by using, for management, a proxy variable obtained from data envelopment analysis and the portfolio quality. The researchers used a sample of 739 banks, 294 of which were failing. A high level of bad debts in the assets was found to be an element contributing to bank vulnerability. On the other hand, management quality was found to be one of the elements that strengthened bank solidity. The probability of bank failure was found to be contra-cyclical in relation to economic circumstances.

Bank supervision organs set up numerous early warning systems aimed at detecting banks that were likely to fail. For instance, in the USA,[7] the Federal Reserve and the other supervisory organs put in place several early warnings instruments. The best known of these is the Federal Reserve's System of Estimating Exam Rating (SEER), which dates back to 1993. Initially known as the Financial Institutions Monitoring System (FIMS) (see Cole and Cornyn, 1995), it enabled the supervision authority to estimate the next bank CAMELS from the data over the previous two quarters. As explanatory variables, the initial version of FIMS combined financial variables and certain socioeconomic indicators.

A similar model is the Statistical CAMELS Off-site Rating (SCOR) developed by the Federal Deposit Insurance Corporation (FDIC). SCOR uses an ordinal logit regression. The CAMELS' prediction for a bank thus takes the following form:

$$Sp = \sum_{k=1}^{5} kp(k)$$

where k is the possible level of CAMELS (1-5) and P(k) is the predicted probability that the bank has the CAMELS k. The model's output for a given bank is given in Table 5.

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7 In France, the Banking Commission set up the SAABA (System for Assistance in Bank Analysis) system in 1997. Its aim is to study the future solvency of a lending institution on the basis of estimated future losses.

Table 5: Results of the SCOR model

Rating	Probability (%)
1	3.2
2	55.0
3	36.5
4	4.9
5	0.4
Deterioration probability	41.8
Estimated rating	2.44

Source: Collier et al. (2003).

Table 5 gives the probability for a given bank of obtaining the rating 1 for Categories 1 to 5 and their associated probabilities. A solid bank has a rating of 1 or 2. The probability that the rating of a bank will deteriorate is the cumulative probabilities of obtaining the ratings 3, 4 and 5 (that is, 36.5 +4.9 +0.4= 41.8). The predicted bank rating estimated according to the formula above is 2.44[8].

It should be pointed out that in sub-Saharan Africa, some studies have been done on the prediction of bank difficulties. One example is the article by Adedoyin Soyibo et al. (2004) published by the African Economic Research Consortium (AERC). This article, after a critical review of the rating system of the CAMEL type used in Nigeria, suggests ways in which the system could be improved and proposes a model of banking failure prediction. Also focussing on Nigeria, Ikhide and Alawode (2001) used the discriminant analysis to distinguish between sound banks and vulnerable ones. Using an econometric approach, Powo Fosso (2000) tried to identify the explanatory factors for banking failures in the UEMOA countries. A monograph was written about banks operating in the Democratic Republic of the Congo by Lukuitshi Lua Nkombe Malaika (2005), who used the principal components analysis and the automatic classification method to discriminate between solid and vulnerable banks.

Finally, Gilbert R.A et al. (1999) came up with a new approach, which consists of examining the credit establishments that will suffer, at some point in the future, a deterioration in their CAMEL rating. The present study followed this new approach.

All in all, the previous studies focussed little on management quality as an explanatory factor for bank deterioration. We are actually not aware of any study about the CEMAC countries that included management quality among the factors explaining bank deterioration. The present study therefore aimed to bridge this gap. The study does not tackle this issue from a static approach, as did the first generation of studies that relied only on early warning systems, but from a dynamic one that groups together the CAMELS variables into structural factors on the one hand, and factors based on current economic circumstances on the other hand.

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8 This predicted bank rating has been estimated by calculating the weighted mean of probabilities using ratings as weights.

4. Methodology

The concept of bank deterioration

Deterioration can be explained as the progressive change from a supposedly good state into one that is supposed to be bad. It is thus a dynamic and gradual phenomenon, which in practice means a transition from a higher class to a lower one, or from a good situation to a bad one. Credit rating agencies refer to this concept every time the economic and financial conditions of a firm, or even of a country, deteriorate, thus causing those agencies to downgrade their rating of the firm.

When applied to the notion of bank supervision, deterioration refers to the downgrading of banks from a given category deemed to be favourable to a lower one that is deemed to be unfavourable. The widespread use of early warning systems, such as the CAMEL(S) ratings used by bank supervisors, enables the latter to distinguish between sound and solid banks and those that are vulnerable, that is, those whose financial conditions are worsening and whose ratings are going to be downgraded some time in the future. Thus, following Gilbert R.A et al. (2000), we hypothesize that the bank supervisor's capacity to predict the deterioration of the financial situation or the rating of banks is essential for bank supervision in environments where bank failures are becoming rather rare.

Therefore, since inadequate capitalization usually precedes bank deterioration, Julapa et al. (2000) and Abdennour et al. (2008) defined the latter as a situation of undercapitalization where the equity-to-assets ratio is lower than a given threshold (5%). Because of this, Julapa et al. (2000) went further and developed two early warning models to predict the financial distress of banking institutions as a function of the decline in their creditworthiness ratios; the models used logistic and neuronal approaches for the period 1988 to 1990.

The operational definition of bank deterioration used in the present study is similar to that of Julapa et al. (2000). We thus used the creditworthiness ratio, which we set at 15% as the dependent variable to discriminate between solid and vulnerable banks. The choice of the creditworthiness ratio is justified not only because it is easy to use and available for use, but also because it is a reliable indicator of the financial solidity of banks. As for the 15% threshold, we fixed it well knowing that the regulatory threshold set in the Basel regulations is 8% and that the mean and the median of the creditworthiness ratios for the period under study are 15.4% and 11.5%, respectively. In this regard, the IMF and the World Bank were correct in 2006 when they evaluated the financial system of the CEMAC area, to use an average creditworthiness ratio of 14.8% for all the banks in the CEMAC countries for the year 2005, because the minimum regulatory threshold of 8% would not have been stringent enough for the sub-region, as it would not have reflected the level of the real risks.

In fact, the thresholds of the creditworthiness ratio can vary from one country to another, depending on the local economic environment, since the Basel threshold is an indicative minimum, after all. In the USA, for example, with the adoption of the Federal Deposit Insurance Improvement Act in 1991, Prompt Corrective Action was instituted, which calls for the thresholds of the creditworthiness ratio to be 10% and higher for well capitalized banks, 8% and higher for adequately capitalized banks, less than 8% for undercapitalized banks, and less than 6% for highly undercapitalized banks. In sub-Saharan Africa, the ratio is 10% in Nigeria and 12% in Kenya. The IMF and the World Bank observed in their report (IMF/World Bank, 2006) a rate of 11.6% of bad debts free of capital provisions in 2005. In relation to this threshold, the banking system in the CEMAC area has sufficient resources to overcome possible future difficulties that might arise from deterioration in the credit portfolio. Therefore, we considered that any bank in the sub-region whose creditworthiness ratio was below the 15% threshold to be vulnerable.

Presentation of data

On the basis of the 15% threshold, we selected a sample of 26 banks for which all the financial data were available for every year from 2001 to 2007.

Table 6: Number of banks in the sample

Bank	Year	Mean credit-worthiness	Median credit-worthiness	Number of banks
Solid	2001	27.8	19	7
	2002	58.1	49	6
	2003	29.8	20	9
	2004	34.5	23.5	6
	2005	27.2	22.5	14
	2006	30.3	20	13
	2007	33.4	29.5	10
	Total	32.7	21	
Vulnerable	2001	6.3	9	19
	2002	6.5	8	20
	2003	7.3	9	17
	2004	4.9	8	20
	2005	3.3	9	12
	2006	6.8	8	13
	2007	4.6	9	16
	Total	5.7	9	
All the banks	2001	12.2	10	26
	2002	18.4	11	26
	2003	15.1	11.5	26
	2004	11.7	10.5	26
	2005	16.2	15.5	26
	2006	18.5	14.5	26
	2007	15.7	11.5	26
	Total	15.4	11.5	

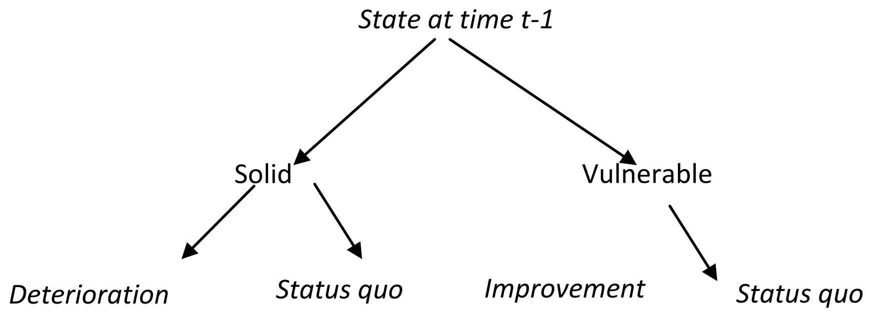
The data used in our study of the deterioration of banks in the CEMAC countries were extracted from the CERBER (Collection, Use, and Release of Regulatory Statements to Banks and Financial Establishments) system used by COBAC.

Data produced by the CERBER system on the balance sheets of banks operating in the CEMAC area are available monthly, quarterly, biannually, and annually, while profit and loss statements are sent to COBAC at the end of every year. For the sake of consistency, in the present study we used annual data of the balance sheets and income statements made in December for the period 2001 to 2007.

The study was also carried out using panel data, considering the shortness of the period under study and, hence, of the small size of the sample. Moreover, the panel data enabled us to construct the transition probabilities matrix, which offers a dynamic view of the phenomenon analyzed using the probability of the transition of modality i to j over time. Finally, panel data also have the advantage of providing us with the possibility of understanding the differences in the behaviour between banks in the different CEMAC countries.

Deterioration modelling strategy and choice of variables

One of the difficulties in modelling deterioration lies in the fact that the explanatory variable, namely, the state of deterioration, is constructed by comparing the states of two consecutive years, as illustrated in the following diagram.



As can be seen in the diagram, the variable illustrating the state of deterioration is complex. Indeed, if one considers the banks in a status quo state, one realizes that they are constituted of solid banks and vulnerable banks that stay in that state.

Conceptually, a strategy of estimating deterioration using a multinomial logit model does not seem appropriate because the independence of irrelevant alternatives (IIA) hypothesis has not been verified. Indeed, the "deterioration" component can only be observed for solid banks, while the "improvement" component can only be observed for the vulnerable banks. Therefore, an ordered multinomial logit model cannot be envisaged either, because it is difficult to classify the various modalities.

One solution, following Yee and Wild (1996), consists in modelling a vector composed of the rating at time t and the rating at time t-1. This actually means estimating a probit or a bivariate logit. The challenge in using this approach lies in choosing explanatory factors. This is because it does not seem logical to explain the rating at time t-1 through variables that are located after time t.

Another solution is taking into account only solid banks at a given time and analyzing those that deteriorated at the following time. But this means reducing the sample size. Given the fact that the sample in our study was already small, and considering the sampling bias inherent in such an approach, we did not deem this approach appropriate for the present study.

Initially, we had thought of using an embedded logit model to overcome such difficulties, but the use of such a model demands that the characteristics that are specific to each component of the explanatory variable are available. In the case of the present study, it was impossible for us to find or construct such variables. So, in view of the non-availability of characteristics for each bank, using an embedded model would have been like using the multinomial model, the limitations of which we talked about earlier.

In fact, the issue under consideration is that of modelling transition states over time. It is not just an issue of comparing, at a given time, the solid banks to the vulnerable ones, as one would do with a logistic regression analysis, a discriminant analysis, or even a multinomial logit, as the discussion of the issue in Glennon and Golan (2003) shows. Consequently, we decided that the analytical model that was appropriate for the present study would clearly be the Markov model (Kalbfleisch and Lawless, 1985; Gentleman, 1994).

It should be pointed out, though, that De Vries et al. (1998) proposed an approach based on the use of an autoregressive logistic regression (ALR) to model transitions. Their proposal was inspired by the model put forward by Bonney (1987). In the present study, we chose to use an ALR model as it is simpler than the complex models proposed by Kalbfleisch and Lawless (1985).

Let us briefly present the ALR model here. Let $Y = (Y_{1,\dots\dots} Y_T)$ be all the binary dependent variables where Yi takes the value 0 for all the solid banks and 1 for the vulnerable ones over T times, and let $X = (X_{1,\dots\dots} X_T)$ be the related covariables. The probability of vector Y that is conditional upon X can be expressed as:

$$Pr(Y/X) = Pr\,(Y1,\dots\, Y_T|\, X)$$
$$= Pr\,(Y_1|X)\, Pr\,(Y_2|Y_1,X)\, \dots\, Pr\,(Y_T|Y_1,\dots,\, Y_{T-1},X)$$

Thus, the corresponding tth logit can be expressed as:

$$\theta_t = log \left[\frac{Pr\,(Y_t = 1|Y_1,\dots,\, Y_{T-1},X_t)}{Pr\,(Y_t = 0|Y_1,\dots,\, Y_{T-1},X_t)} \right]$$

So, the logistic model to be estimated can be expressed as follows:

$$\theta_t = \alpha + \beta X_t + \sum_{k=1}^{t-1} YkZtk$$

Where $_t$ and $_k$ represent the period of time and the bank, respectively, α, represents the constant and β represents the effect of the explanatory variables. Here, Z_{tk} are functions of Y_t . So, at time $_t$, only the delayed *t-1* effects are taken into account in the model. Conceptually,

$$Z_{tk} = 0, K \geq t$$

The coding used for the Zs is:

$$Z_{tk} = \begin{cases} 2Y_t - 1, \text{ if } k < t \\ 0, \text{ if } k \geq t \end{cases}$$

Thus, the autoregressive variables have the three following values: -1, 0, 1, while likelihood can be expressed as:

$$Pr(Y/X) \prod_{t=1}^{T} \theta^{\theta t Y t} / [1 + \theta^{\theta t}]$$

The model's variables

Several studies were consulted to select variables for our model. There is first the study by Gilbert R.A et al. (2002), which used risk-aversion variables (equity and return on assets), variables reflecting the credit risk (loans not paid for a period of 30 to 89 days, loans not paid for a period longer than 90 days, loans to businesses and industries, loans on which interest is no longer calculated, repossessed real property, and housing credit granted to occupants), variables reflecting the liquidity risk (book value of securities, deposit receipts higher than US$100 million), and non-financial variables (asset logarithm, size of the firm, and management quality). Second, there is the study by Gilbert R.A et al. (1999), which describes some variables that are frequently used in early warning systems. In that study, Gilbert et al. measured management quality with a dichotomous variable that was assigned the value of 1 if the rating of the management component was higher than the composite rating of the firm. In the present study, we also included management quality as a variable, but we represented it with a quantitative variable reflecting efficiency within the firm. Third, there are the studies by Barr (1993) and Barr and Siems (1996). Similar to these studies, we chose, as a proxy of the management quality variable, scores of technical efficiency that were obtained by using the DEA method.

The explanatory variables used in our model and their expected signs are summarized in Table 7.

Table 7: Expected signs of variables used in the model

	Variables frequently used in early warning systems	Expected sign
1	Bad debts as ratio of the total gross loans	+
2	Fixed assets as ratio of invested capital	+
3	Gross loans as ratio of total balance sheet	+
4	Credit to insiders as ratio of total loans	+
5	Overhead expenses as ratio of net banking income	+
6	Net income as ratio of total balance sheet	-
7	Liquidity	-
8	Total of deposits as ratio of total balance sheet	-
9	Logarithm of total balance sheet	-
10	Bank's balance sheet as ratio of total balance sheet of the group's banks	+/-
11	Management quality (DEA score)	-
12	Economic environment (growth rate, among others)	+/-

Measuring the management quality

One of the weaknesses of the deterioration prediction models lies in the inadequate assessment of management quality. To overcome this difficulty, we decided to calculate, by way of proxy of management, an advanced indicator composed of efficiency scores. But to enable the construction of efficiency scores, access to income statements from the financial establishments concerned are needed in most cases. We have already seen that in the CEMAC area, banks release their income statements at an annual frequency. That is why we calculated an annual score for each bank.

A banking firm will be said to be efficient if, from a given basket of inputs, it obtains a maximum possible output (technical efficiency), or if it can obtain a given level of output from a possible minimum of inputs (allocative efficiency). Farrell, and Farrell and Fieldhouse (1957; 1962) are among the first pioneers of bank efficiency measurement.

To measure efficiency, one can use a parametric approach by estimating the parameters of the theoretical production function, or a non-parametric approach of the DEA type. We use the latter approach in this study.

Given a sample of n firms characterized by s inputs (x) and m output (y), the efficiency of the firm 0 will be obtained by resolving the following linear approach (Charnes et al., 1978):

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{t=1}^{m} v_t X_{t0}}$$

under the following constraints:

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{t=1}^{m} v_t X_{tt}} \leq 1; j = 1 ..., n$$

and with the following weightings: $U_r, V_t \leq 0; r = 1,\ldots,s;\ t = 1,\ldots,m$

The resolution of this primal programme can turn out to be complicated if the number of firms is very high, as there are as many constraints as there are firms. That is why a dual programme was used where the number of constraints depended only on the number of inputs. Working within a context of panel data, we calculated a DEA score for each bank and each period.

In order to arrive at this score, we used the DEA method with the variables stated in Table 8.

Table 8: Variables used in computation of DEA scores

Variables used	
Revenues (y)	Bank trading revenues
	Incidental revenues
	Reversals of provisions
	Other revenues
Expenses (x)	Bank operating costs
	Staff costs
	Provisions and depreciation expenses
	Other expenses

The computed score is described in Table 9.

Table 9: Efficiency measurements

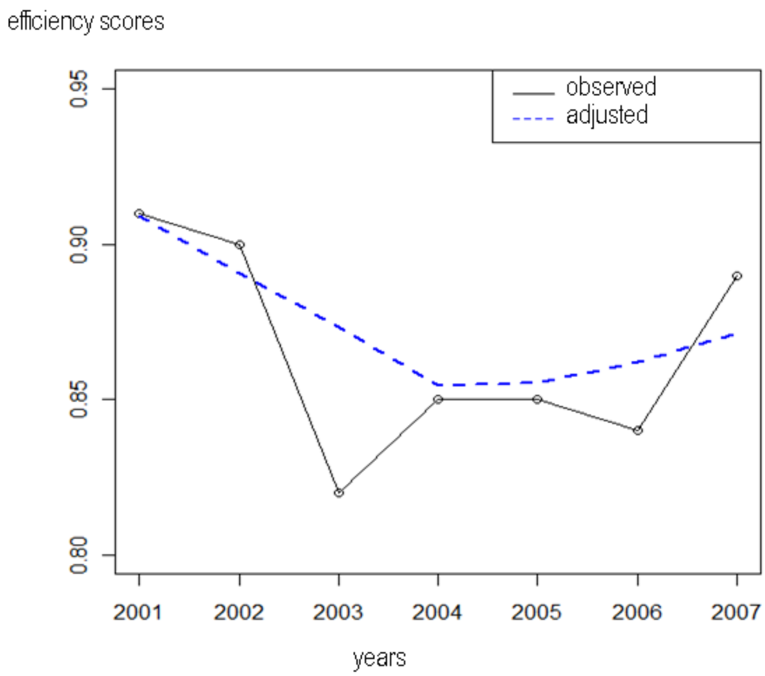
	Mean	Standard deviation	Minimum
2001	0.91	0.14	0.48
2002	0.90	0.13	0.55
2003	0.82	0.20	0.27
2004	0.85	0.20	0.36
2005	0.85	0.18	0.46
2006	0.84	0.15	0.51
2007	0.89	0.15	0.57

Source: Authors' computations .

Table 9 and Figure 1 both show a drop in the management quality score between 2001 and 2003, and 2005 and 2006. The score rose again from 2004 to 2005, and from

2006 and 2007, but without reaching its initial level. So, it appears that bank management quality is most likely a major problem in the CEMAC area.

Figure 1: Trends in bank efficiency scores from 2001 to 2007



Source: Authors' computations

Other variables of the model

For financial variables, we took into account the variation of the parameter between year t and year t-1, as a ratio of the assets of year t-1 (Cole et al., 1995). In terms of macroeconomic environment variables, we used the GDP growth rate, inflation, and the fluctuation of the real effective exchange rate. We thus constructed an indicator of bank portfolio concentration (For each bank, we calculated the Herfindahl index for the major risks, which in the CEMAC area are commitments that are higher than 15% of shareholders' equity).

Table 10: Financial variables of the model

	Solid banks	Vulnerable banks	All
Bad debts/total loans	0.165	0.163	0.164
Fixed assets/invested capital	0.160	0.077	0.106
Total loans/total assets	0.569	0.618	0.601
Investment loans/total loans	0.043	0.046	0.045
Housing credit/total loans	0.030	0.021	0.024
Equipment loans/total loans	0.089	0.083	0.085
Consumer credit/total loans	0.056	0.025	0.036
Credit to insiders/total loans	0.021	0.019	0.020
Overheads/net banking income	1.001	0.563	0.720
ROA	0.020	0.011	0.015
Liquidity ratio	2.794	1.887	2.211
Cash balance/total assets	0.10	0.19	0.145
Total deposits/total assets	0.266	0.240	0.249
Size	11.074	11.283	11.209
Size within the group	0.639	0.651	0.646
Interbank operations balance/ total balance sheet	0.000	0.003	0.002
Currency transactions/total balance sheet	0.096	0.035	0.057
Management score	0.933	0.944	0.940
Big risks portfolio concentration	0.267	0.154	0.194

Source: Authors' computations

It transpires from Table 10 that loans, overheads, liquidity, size, and management score are significant variables, and have relatively the same weight for both solid and vulnerable banks, except for overheads. On the other hand, the weight of loans to specific sectors, of ROA, currency transactions, and interbank operations, is very small and is relatively the same for both solid and vulnerable banks. The weight of the variables concerning deposits and concentration is moderately high.

The matrix of the correlation of variables shows that all these are independent of each other, with the exception of cash balance and loans. That allowed us to use most of the variables.

5. Results

Presentation of the results of the model

We used data covering the period from 2001 to 2007. Initially all the identified variables were included but later, through a stepwise procedure, we obtained a parsimonious model. For a better interpretation of the coefficients of the explanatory variables, in addition to marginal effects we calculated the odds ratios[9] for a 1% variation in these variables. The autoregressive terms corresponding to the six preceding years were also considered for each bank. It transpires from the calculations that the order-6 (z1) autoregressive terms were significant. The positive sign for their coefficient reflects the inertia observed in a given state. The order-5 (z2) had a negative coefficient, which reflects an improvement in the situation of some of the vulnerable banks for 2006.

With regard to the other financial variables, it can be observed that the increase in credit to insiders, the size of the bank and its size within the group, clearly seem to be factors that lead to bank vulnerability. Housing credit, overhead expenses, ROA, liquidity, currency transactions and the management score all contribute to a reduction in bank deterioration. As for the impact of macroeconomic factors, it does not seem to be significant, except for the real effective exchange rate. The results obtained show that credit to insiders, the size of the bank in the group, housing credit, ROA, liquidity, and the real effective exchange rate were statistically significant and had more or less the expected signs for their coefficients.

In relation to the variable "country" as a factor, it was found to be significant for the Republic of Congo, Equatorial Guinea and Chad, but not for Cameroon.

9 In a logistic regression model, the calculated coefficients are not easy to interpret because they reflect the effect of the variation in the explanatory variables on a function of the probability of the studied event and not on itself; the function in question is the logit function $\log\left(\frac{p}{1 - p}\right)$. A more suitable interpretation is linked to the use of the odds ratios or ratings ratios, which reflect the ratios between the probabilities of observing the event of interest under different conditions. For a binary or qualitative variable, an odds ratio corresponds to the exponential of the coefficient and can be interpreted as the ratio of the probability of achieving the event under the modality under study to the probability under the modality of reference.

Table 11: Results of the full model

	Coeff.	SE	z	P>z	c	OR	ME	SE	z	P>z
z1	2.46	0.62	3.94	0.00						
z2	-0.43	0.68	-0.63	0.53						
z3	0.46	0.56	0.82	0.41						
z4	0.90	0.63	1.43	0.15						
z5	0.57	0.77	0.75	0.46						
z6	1.32	0.93	1.41	0.16						
Bad debts/total loans	3.33	4.49	0.74	0.46	1%	1.03	0.53	0.69	0.77	0.44
Fixed assets/ invested capital	0.25	0.46	0.54	0.59	1%	1.00	0.04	0.07	0.55	0.58
Total loans/total assets	2.11	3.91	0.54	0.59	1%	1.02	0.34	0.63	0.54	0.59
Investment loans/total loans	-6.41	5.64	-1.14	0.26	1%	0.94	-1.03	0.92	-1.12	0.26
Housing credit/ total loans	-34.37	14.06	-2.44	0.02	1%	0.71	-5.52	2.26	-2.44	0.02
Equipment loans/total loans	1.57	5.61	0.28	0.78	1%	1.02	0.25	0.90	0.28	0.78
Consumer credit/total loans	2.96	8.49	0.35	0.73	1%	1.03	0.47	1.34	0.35	0.72
Credit to insiders/total loans	18.27	10.40	1.76	0.08	1%	1.20	2.93	1.65	1.78	0.08
Overheads/net banking income	-0.53	0.46	-1.16	0.25	1%	0.99	-0.09	0.08	-1.13	0.26
ROA	-45.27	20.63	-2.19	0.03	1%	0.64	-7.27	3.31	-2.19	0.03
Liquidity ratio	-0.53	0.50	-1.05	0.29	1%	0.99	-0.09	0.08	-1.01	0.31
Cash balance/ total assets	0.97	3.21	0.30	0.76	1%	1.01	0.16	0.52	0.30	0.76
Size of the bank	1.49	0.55	2.73	0.01	0.095	1.15	0.24	0.09	2.70	0.01
Size within the group	2.68	1.59	1.69	0.09	1%	1.03	0.43	0.22	2.00	0.05
Interbank operations balance/										
Total balance sheet	7.69	11.73	0.66	0.51	1%	1.08	1.24	1.87	0.66	0.51
Currency transactions/ total balance sheet	-1.85	1.25	-1.48	0.14	1%	0.98	-0.30	0.21	-1.45	0.15
Management score	-2.93	2.39	-1.22	0.22	1%	0.97	-0.47	0.38	-1.24	0.22

Big risks portfolio concentration	-0.44	1.51	-0.29	0.77	1%	1.00	-0.07	0.24	-0.29	0.77
GDP growth	-0.02	0.04	-0.61	0.54	1%	1.00	0.00	0.01	-0.61	0.54
Inflation	-0.08	0.07	-1.20	0.23	1%	1.00	-0.01	0.01	-1.17	0.24
REER	-5.87	2.35	-2.50	0.01	1%	0.94	-0.94	0.39	-2.42	0.02
Shareholding										
Public	Ref						ref			
Private foreign	2.71	1.70	1.60	0.11		15.05	0.54	0.31	1.72	0.09
Private domestic	1.51	1.90	0.80	0.43		4.54	0.18	0.17	1.10	0.27
Country										
Cameroon	Ref						ref			
Central African Republic	-0.43	1.74	-0.24	0.81		0.65	-0.08	0.34	-0.22	0.82
Congo	5.87	2.51	2.34	0.02		355.53	0.24	0.06	3.74	0.00
Gabon	1.17	1.21	0.97	0.33		3.23	0.15	0.12	1.25	0.21
Equatorial Guinea	5.51	2.68	2.05	0.04		246.64	0.28	0.08	3.48	0.00
Chad	3.73	1.69	2.21	0.03		41.72	0.33	0.10	3.28	0.00
Constant	-16.25	7.86	-2.07	0.04						

OR: odds-ratio; ME: marginal effect; SE: standard error; c: variation invariables X i

AIC: 179.147	Obs.	=	175
	LR chi2(32)	=	119.55
	Prob > chi2	=	0
Likelihood log=-54.573343	Pseudo R2	=	0.5227

It clearly transpires from the results of the full model that the credit to insiders, the size of the bank, its size within the group, and shareholding have a positive effect on the probability of bank deterioration within the CEMAC area. While the effect of shareholding was not found to be significant, the effect of credit to insiders and the size of the bank within the group was significant at 10%, and that of the size of the bank was significant at 1%.

A look at the odds ratio (OR) shows that a 1% increase in the credit to insiders corresponds, other things being equal, to a 20% increase in the probability of bank deterioration. This observation simply tends to confirm the observations made by on-site audit exercises that pointed out the excessive granting of loans to shareholders, the management and staff of some of the banks in the CEMAC area. This is one of the major causes of the deterioration of the financial situation of the banks in question.

A 1% increase in the size of the bank was found to lead to a 3% increase in the probability of bank deterioration, while a 1% increase in the size of the bank in the group led to a 15% increase in this probability. That is, the bigger the bank grows, the higher the risk of bank deterioration. This risk is higher in the case of a group bank, as the temptation is also greater to take ill-considered risks. Such a bank is usually exposed to a greater leverage effect that is capable of rendering it more vulnerable to shocks and risk of contagion.

Private foreign and domestic shareholding was found to expose banks to deterioration more than public shareholding. However, its effect is not significant. Indeed, while at a 15% creditworthiness ratio, banks holding private domestic capital are more prone to deterioration than banks holding private foreign capital due to multiple problems of management and governance, beyond that, percentage private banks holding domestic capital have more secure equity than private banks with foreign capital. Banks in this latter category are more sensitive to the cost of opportunity of holding own funds, a cost that is relatively high. They are more subject than domestic banks (be they private or state-owned) to more frequent arbitrage operations and greater pressure from their head offices, whose goals are to make profit and pay dividends. State-owned domestic banks and private banks whose capital is essentially held by the state or by some individuals, often from the same family, more readily accept the idea of transforming profits into reserves.

Housing credit, overheads, ROA, liquidity, currency transactions, the management score, and the real effective exchange rate (REER) were found to have a reverse effect on the probability of bank deterioration. But, while the effect of overheads, liquidity, currency transactions and the management quality was not statistically significant, that of housing credit and ROA was significant at the 5% level, and that of the REER at the 1% level. The REER turned out to be the only exception: a 1% increase in the REER would reduce the probability of bank deterioration by 6%, while the same rate of increase in housing credit and ROA would reduce it by 29% and 36%, respectively.

Housing credit and ROA reduce the probability of bank deterioration in a comparable way. An increase in housing credit strengthens bank profitability because this category of loans is usually well protected. It is obvious that an increase in profitability increases the levels of equity and thus reduces the probability of bank deterioration.

The management quality, measured by the DEA score, was found to have the expected sign, thus confirming the idea that good management reduces the probability of bank deterioration. However, it was not found to be significant from a creditworthiness ratio of 15%. In practice, if a creditworthiness ratio of up to 10% or 11% of the management quality for the banks in the CEMAC area is significant at 5%, then with a ratio of 15% the management quality can no longer be taken as a significant factor in the explanation of bank deterioration.

With the exception of the REER, the other economic environment variables tested (namely GDP growth and inflation) were not found to be significant. The REER was significant at the 1% level and its coefficient had the expected sign. Within the CEMAC area, where there is fixed exchange rate parity vis-à-vis the euro, the impact of external competitiveness on the probability of bank deterioration is certain. So, by strengthening their external competitiveness, the countries in this sub-region are automatically consolidating their banks while at the same time reducing the probability of bank deterioration. In relation to that, the 2006 report by the IMF and the World Bank (IMF/World Bank, 2006) on the assessment of the financial sector within the CEMAC area argued that a devaluation of the CFA franc would have quite a positive effect on the banking sector.

Finally, the effect of the variable "country" was analyzed comparatively, with Cameroon as the reference country. In this connection, Congo, Equatorial Guinea and Chad were found to be significant, with the signs of their respective coefficients positive. In other words, the probability of bank deterioration in these three countries was found to be higher than in Cameroon or in Gabon; the latter two countries have the most capitalized banks in the CEMAC area.

Table 12: Results of the parsimonious model

	Coeff.	SE	Z	P>z	c	OR	ME	SE	z	P>z
z1	1.83	0.40	4.53	0.00						
z4	0.96	0.45	2.14	0.03						
z6	1.49	0.77	1.93	0.05						
Housing credit/total loans	-24.68	9.83	-2.51	0.01	1%	0.78	-4.82	1.93	-2.50	0.01
Overheads/net banking income	-0.45	0.74	-0.60	0.55	1%	1.00	-0.09	0.15	-0.58	0.56
ROA	-33.91	14.84	-2.28	0.02	1%	0.71	-6.63	3.00	-2.21	0.03
Liquidity ratio	-0.73	0.38	-1.90	0.06	1%	0.99	-0.14	0.08	-1.79	0.07
Size	0.95	0.36	2.61	0.01	0.095	1.09	0.19	0.07	2.56	0.01
Currency transactions/total balance sheet	-2.32	0.97	-2.38	0.02	1%	0.98	-0.45	0.19	-2.44	0.02
Inflation	-0.10	0.06	-1.69	0.09	1%	1.00	-0.02	0.01	-1.70	0.09
REER	-3.96	1.85	-2.14	0.03	1%	0.96	-0.77	0.37	-2.12	0.03
Country										
Cameroon										
Central African Republic	-0.34	1.19	-0.29	0.77		0.71	-0.07	0.26	-0.27	0.79
Congo	1.58	1.13	1.40	0.16		4.85	0.21	0.09	2.21	0.03
Gabon	0.63	0.82	0.77	0.44		1.88	0.11	0.13	0.85	0.40
Equatorial Guinea	2.52	1.19	2.13	0.03		12.44	0.27	0.08	3.52	0.00
Chad	2.04	0.95	2.14	0.03		7.68	0.29	0.10	2.77	0.01
Constant	-6.59	4.25	-1.55	0.12						

AIC: 154.874	Number of obs.	=	175
	LR chi2(20)	=	107.82
	Prob > chi2	=	0.0000
Likelihood log. = -60.436843	Pseudo R2	=	0.4715

The parsimonious model offers results that are almost similar, but more consistent, than the very first model. The autoregressive terms of the orders of 6, 3 and 1 are statistically significant and with positive coefficients, which reflects, as in the full model, the effect of inertia (status quo in the diagram of the deterioration state). Most of the financial variables are statistically significant at the 1% and 5% levels. Housing credit, ROA, liquidity ratio, currency transactions, inflation, and the REER all contribute to reducing the probability of bank deterioration in the CEMAC area, while the size of the bank contributes to increasing it. As for the effect of a given country in the sub-region being compared with Cameroon, it was found significant only for Equatorial Guinea and Chad. This means that banks in the latter two countries are more vulnerable than those in the other CEMAC countries, whose risk of deterioration is less because they are more capitalized.

6. Quality of the model

Validating the model requires calculating the type-I and type-II errors. We achieved this validation using the full model. By relating the observed state of banks to the predicted one, the contingency table, Table 13, is produced.

Table 13: Contingency table

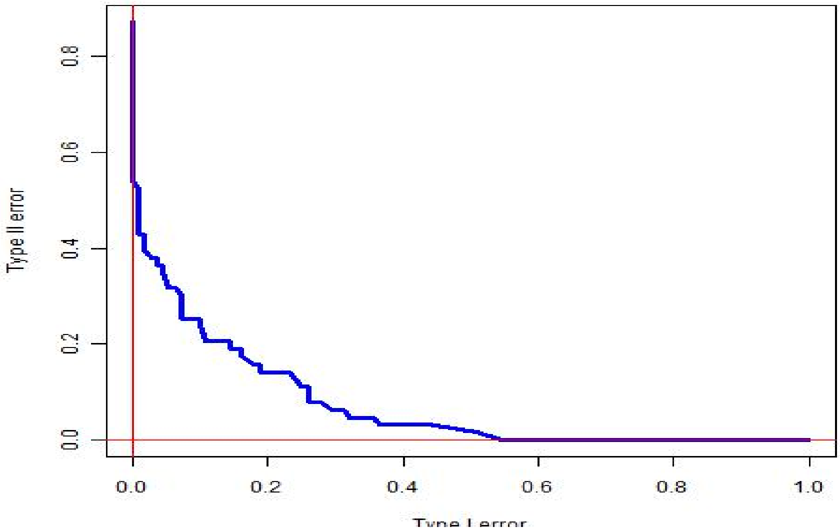
Observed state	Predicted state		
	Solid	Vulnerable	Total
Solid	22.9	13.1	36.0
Vulnerable	2.9	61.1	64.0
Total	25.7	74.3	100.0
Correct rankings	84.00%		
Type-II error	36.51%		
Type-I error	4.46%		
Kappa statistic	0.6296		
Cramer's V	0.6483		

It can be seen that the rate of correct predictions is quite high (84.00%). Cohen's kappa statistic, which reflects the degree of concordance between a model's predictions and the observed values, is also high (kappa= 0.6296). Indeed, the higher its value (i.e. close to 1), the more concordant the predictions. The same can be said about the Cramer coefficient (V, in this case), which signals a string association (its value is higher than 0.4). The values obtained for the type-I and type-II errors are 4.46% and 36.51%, respectively.

It should be noted here that the figures above were obtained by predicting that all the banks whose predicted deterioration probability was higher than 35% were vulnerable, with the dependent variable being the state of deterioration fixed as a function of the 15% threshold of creditworthiness. This model produced the lowest type-I error, and the curve that relates the errors to each other has few irregular bends, as can be observed in Figure 2.

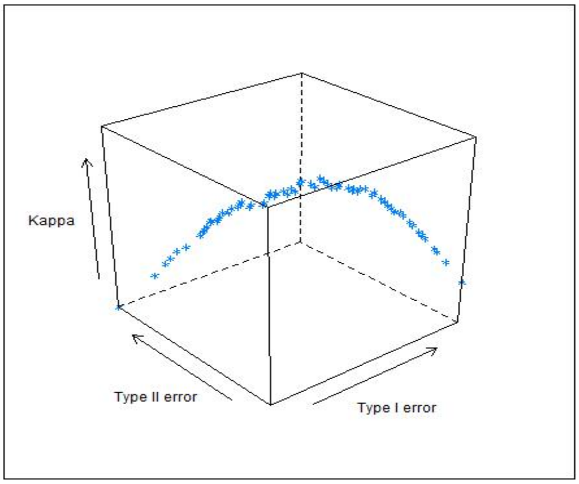
On the same curve, it is evident that from a probability threshold close to 35%, the type-II error is relatively higher, while the type-I error decreases continuously. With the perfect model being one that is close to the origin, we thus chose to use the 35% threshold so as to minimize the type-I error, which is the objective that a bank supervisor seeks to achieve.

Figure 2: Presentation of type-I and type-II errors



We further produced a three-dimensional representation, based on the same graph (Figure 3), of the type-I error, the type-II error, and the kappa statistic. It also turns out that the choice made corresponds to the maximum value for the kappa statistic.

Figure 3: Presentation of type-I and type-II errors and Cohen's kappa statistic



7. Out-of-sample simulations

We carried out an out-of-sample simulation using the computed full model. To this end, we used data for the year 2009 to predict the state of banks in 2009. We assumed that a bank was vulnerable when the bank deterioration probability was higher than 35%, as we did when we validated the model using data from the sample. Table 14 summarizes the results we obtained.

Table 14: Results of out-of-sample simulations

Bank	State in 2009	State predicted for 2009	Deterioration probability
1	1	1	0.998795
2	1	1	0.999842
3	1	1	0.998221
4	1	0	0.998920
5	1	1	0.999780
6	1	0	0.636453
7	1	1	0.998931
8	1	1	0.999690
9	1	1	0.725119
10	1	1	0.998733
11	1	0	0.972348
12	0	1	0.000000
13	0	1	0.000000
14	0	0	0.000000
15	1	0	0.999989
16	1	0	0.999979
17	1	1	0.999977
18	1	0	0.999997
19	0	0	0.000000
20	0	0	0.000000
21	0	0	0.000000
22	0	0	0.000000
23	0	0	0.000000
24	0	0	0.000000
25	0	1	0.000000
26	1	0	0.999999
27	1	1	0.999996
28	1	0	0.999543
29	1	1	0.993373
30	1	1	0.994622
31	1	0	0.994984
32	1	1	0.998406
33	1	1	0.990243
34	1	1	0.999955
35	1	1	0.999543
36	1	0	0.942133

0 = solid; 1 = vulnerable

The synoptic view given in Table 15 shows that the model is less effective with data taken from outside the sample. This observation is usually made for models of supervised prediction or learning (Hastie et al., 2001).

Table 15: Synoptic view of out-of-sample simulations

	Bank state predicted for 2009		
State observed in 2009	Solid	Vulnerable	Total
Solid	19.4	27 .8	47.2
Vulnerable	8.3	44.4	52.8
Total	27.8	72.2	100.0
Type-I error	0.16		
Type-II error	0.58		

Of the 36 banks used in the prediction, the model predicted 17 (i.e. 47.2%) to be solid, and 19 (i.e. 52.8%) to be vulnerable. Of the 17 predicted to be solid, 7 (i.e. 19.4%) were indeed found to be solid as at 31 December 2009, while 10 (i.e. 27.8%) turned out to be vulnerable in the same period. This corresponds to a type-II error of 58%. As for the 19 banks that were predicted to be vulnerable, 16 (i.e. 44.4%) were indeed found to be vulnerable as at 31 December 2009, while 3 (i.e. 8.3%) were found to be solid. This represents a type-I error of 16%. It is the type-I error that the bank supervisor seeks to minimize.

The results above can be explained by the small size of the sample used. Nonetheless, far from rendering the model useless, the same results revealed a new typology of banks. Thus, from the predictions of the model, we will consider that a bank is solid if the model predicts it to be solid and if its state observed at the time of the prediction in question is indeed deemed to be solid. Conversely, all the other banks will be considered vulnerable. So, for a vulnerable bank predicted to be solid, it is easy to draw the conclusion that the level of shareholders' equity is its principal point of vulnerability.

Likewise, if a bank that is solid at a given time is predicted to be vulnerable, this means that, from the point of view of its financial situation, it presents important signs of weakness that are not apparent from just the sole risk cover. Most of the state-owned banks are in such a situation because, even though they have enough equity and are thus solid to start with, they will be predicted to be vulnerable.

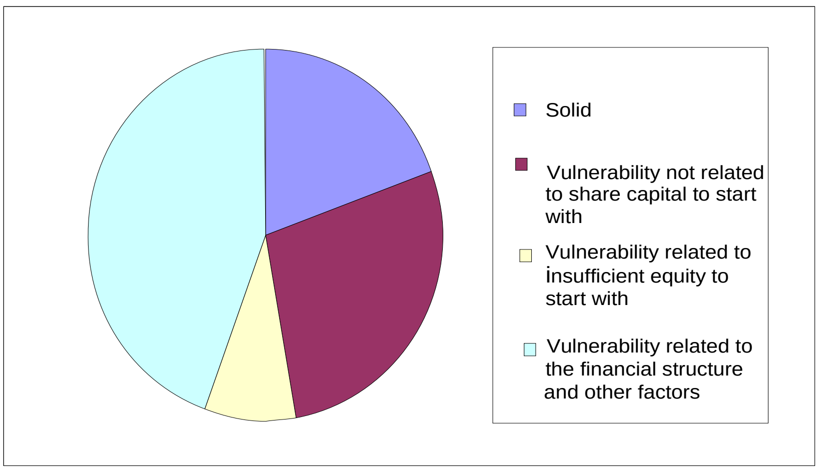
In either case, the vulnerable banks are those that present signs of weakness related both to shareholders' equity and other factors (management quality, governance and economic environment). This new typology of the banking system in the sub-region as at 31 December 2009 is summarized in Table 16.

Table 16: New typology of the banking system

Bank state		Number of banks	%
Solid		7	19.4
Vulnerable	-	Vulnerability not related to shareholders' equity to start with	
-	Vulnerability related to insufficient equity to start with		
-	Vulnerability related to the financial structure and other factors	10	27.9
		3	8.3
		16	44.4
Total		36	100.0

Figure 4 illustrates this new bank typology.

Figure 4: New typology of banks



On the basis of this new typology, the bank supervision authorities can better prioritize and adapt their interventions depending on the difficulties specific to each bank. While there would be less supervision of the banks in the first category, it is expected that there would be close supervision of those in the other categories. However, in this first category that is predicted to be solid, we observed that as at 31 December 2009, there were five banks that were very highly capitalized, with a risk cover ratio equal or more than 20%, while two other solid banks were not that much capitalized, with creditworthiness ratios of only 17% and 18%. This division into two groups of banks that were predicted to be solid brought us to envisage a five-category typology, which is akin to the Prompt Corrective Action (PCA) devised in the USA in 1991 by the Federal Deposit Insurance Corporation (FDIC). The PCA has five categories according to the creditworthiness ratio, as in the present study. However, while the PCA in the USA is an ex-post intervention, the typology we are proposing here would rather call for an ex-ante intervention. The corrective actions to be taken should, in the CEMAC area more than anywhere else, be determined within a framework of clear measures taken by the bank supervision authority when a bank has been predicted to be vulnerable.

Moreover, if a bank is predicted to be solid while its history presents signs of weakness, it should also be classified as vulnerable.

8. Policy measures

For a prompt corrective action to be effective, the bank supervision authority must enjoy independence vis-à-vis the judicial and political system, but must also be accountable. In sub-Saharan Africa, as elsewhere, banking issues are high-stake matters that are discussed by and subjected to the approval of the political and judicial authorities. In countries in francophone Africa, where there is a uniform corporation law, an untimely intervention on the part of a judge by way of prompt corrective action is something much feared by the supervision authority as that can weaken this authority. In the specific case of the CEMAC area, where bank supervision is the remit of a supranational authority, it would be possible to strengthen the legal framework by enacting laws that would specifically govern the resolution of bank difficulties, laws that would go as far as enabling the closure of banks without requiring prior intervention of the judiciary and the political system.

The appropriate measures to be taken by the supervision authority to ensure that an effective prompt corrective action is taken in real time will depend on the categories of banks. Those measures include the following: more restrictive prudential norms, close supervision, limiting certain operations, reducing the size of the bank, recapitalization, forced sale of assets, suspension of paying dividends to shareholders, suspension or sacking of the management, putting the bank into receivership, withdrawing the operating licence, and liquidating the bank. The last two measures mentioned must take place when the level of capital is such that the cost for the taxpayers and the depositors is not too high.

As pointed out earlier, the implementation of all those measures requires a reform of the banking crisis resolution framework and must clearly dissociate the prompt corrective action by the supervision authority from any judicial or political intervention. The prompt corrective action thus requires a prior reform of the legal and institutional apparatus and a clear statement of the supervision authority's goals in order to protect depositors and avoid a systemic risk, the cost of which would definitely be too high for the taxpayer.

Furthermore, the rules of intervention must be clear in the case of undercapitalization or, if need be, of closing a bank. Taking this latter, and extreme, action necessitates a fair amount of foresight and perhaps courage in order to decide to liquidate a bank, which still has enough shareholders' equity. In sub-Saharan Africa, and in the CEMAC area in particular, prompt corrective action would most likely be feasible in view of the efforts already made by the countries in the region to entrust bank supervision to a supranational authority. Without this type of authority, any claim to be able to achieve bank supervision would be doomed to failure. This approach is therefore more than urgent in jurisdictions that aim to set up a deposit guarantee fund; without such a fund, the cost of banking crises would entirely be incurred by taxpayers.

Nonetheless, while PCA strengthens the tools of microprudential supervision, the PCA system cannot be the sole tool at the disposal of the supervision authority to anticipate bank crises and, beyond that, to ensure financial stability. It has been proven that the economic environment influences the probability of deterioration of the financial situation of banks by sometimes increasing it. Therefore, in order to achieve the expected results, prompt corrective action must be part of an overall framework for macroprudential supervision so as to minimize the systemic risk arising from banking crises. More and more, central banks and other prudential authorities are putting in place systems for macroprudential supervision that cover not only the banking sector but also the financial and insurance markets.

Conclusion

The aim of this study was to put forward a model capable of predicting bank deterioration that could happen in a year's time, a model that takes into account financial variables, the quality of management, and economic environment variables. We have effectively constructed an autoregressive logistic model, and the results of it seem satisfactory. In relation to this, the management proxy variable (the DEA scores), inflation and the REER were all found to have the expected sign. However, at the 15% threshold of the creditworthiness ratio, only the REER and inflation were found to be statistically significant. Among the financial variables, those that were found significant are: credit to insiders, size of the bank, size of the bank within the group of banks, housing credit, ROA, and the liquidity ratio. But while the first three in this list were found to have a positive effect on the probability of bank deterioration, the remaining three had a negative effect. The effect of bank deterioration was greater in Congo, Equatorial Guinea and Chad than in Cameroon – which was taken as the reference country in this study. That means that the banks in the aforementioned three countries seem to be more vulnerable for being undercapitalized.

The model we have proposed offers a rate of accurate prediction that is quite high (84%), with a type-I error of 4.46% and a type-II error 36.56%. This is proof of its good prediction capacity. However, the simulations we did using data from outside the sample have revealed that the model is less effective in this case, with a type-I error of 16% and a type-II error of 58%. It should be noted that the type-I error is the one that the bank supervision authority would want to minimize. So, this result, which can be explained by the small size of the sample, is far from rendering the model useless; it has actually brought to light a new, five-category typology of banks that is similar to the one related to the PCA in force in the USA. However, while the PCA in the USA is an ex-post intervention, the model developed in the present study would enable the supervision authority to act ex-ante. The corrective actions to be taken should, in the CEMAC area more than anywhere else, be determined within a framework of clear measures taken by the bank supervision authority when a bank has been predicted to be vulnerable.

The model we are proposing here can help the bank supervision authority to predict the bank deterioration probabilities one year before the deterioration. It can enable this authority to better target the banks for which priority action is needed and to allocate financial and human resources more efficiently. It should be noted in passing that these resources are very limited in the face of the ever-increasing number of authorized banks.

Moreover, our model, which is applicable to banks operating from a number of countries, has also revealed the specificities of each one of these, as evidenced by the significant effects on three of them (Congo, Equatorial Guinea, and Chad).

An autoregressive logistic model, applicable to multiple states of bank deterioration, and one that models this deterioration by taking into account financial variables, an advanced indicator of the quality of management, and the real effective exchange rate, is the first of its kind within the CEMAC area and, most certainly, in the Franc Zone countries. To this extent, it is a piece of real innovation in the bank supervision domain in emergent economies, especially at this time of resurgence of banking crises around the world. However, its applicability will hinge on the implementation of a wide range of legal and institutional reforms that would be indispensable for an effective PCA. This PCA alone would not be enough to prevent systemic banking crises; it must be part of a wider framework for macroprudential supervision aimed at ensuring financial stability.

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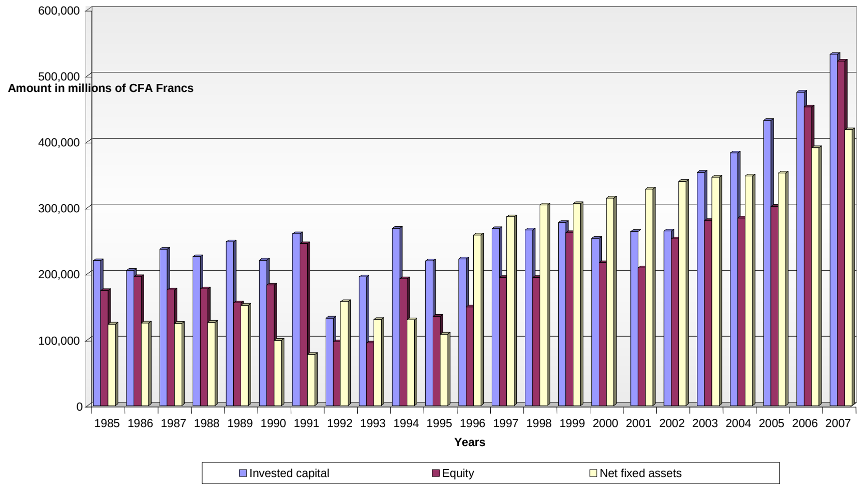
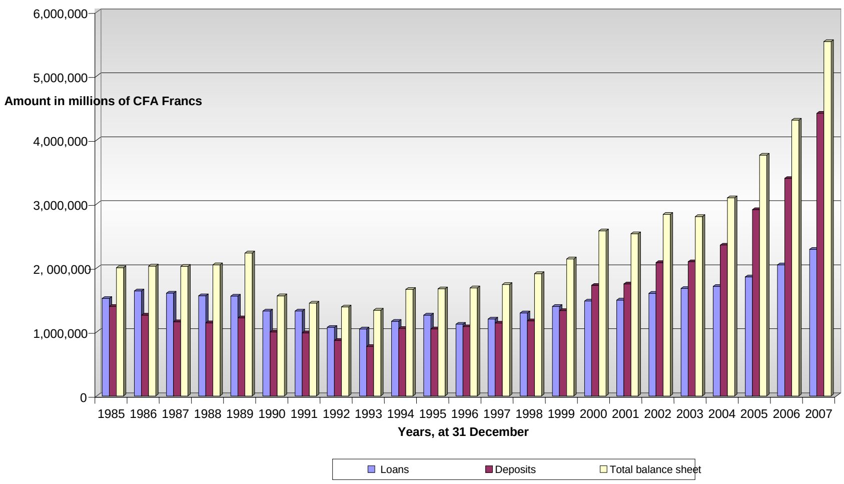
ANNEXURE

A1: Trends in some aggregates and statistics in the CEMAC banking sector

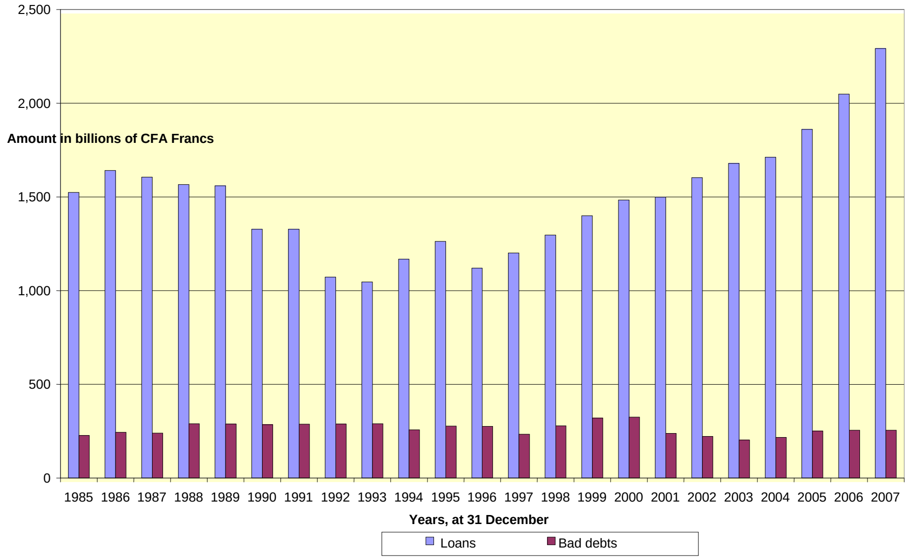
Trends in invested capital, equity, and fixed assets of banks in the CEMAC area



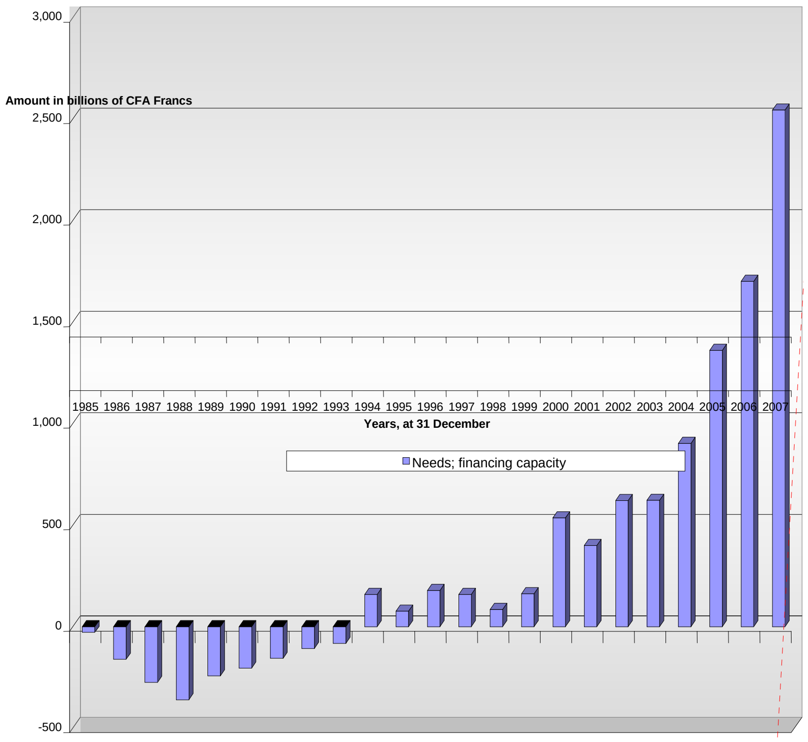
Trends in loans, deposits and total balance sheets of banks in the CEMAC area

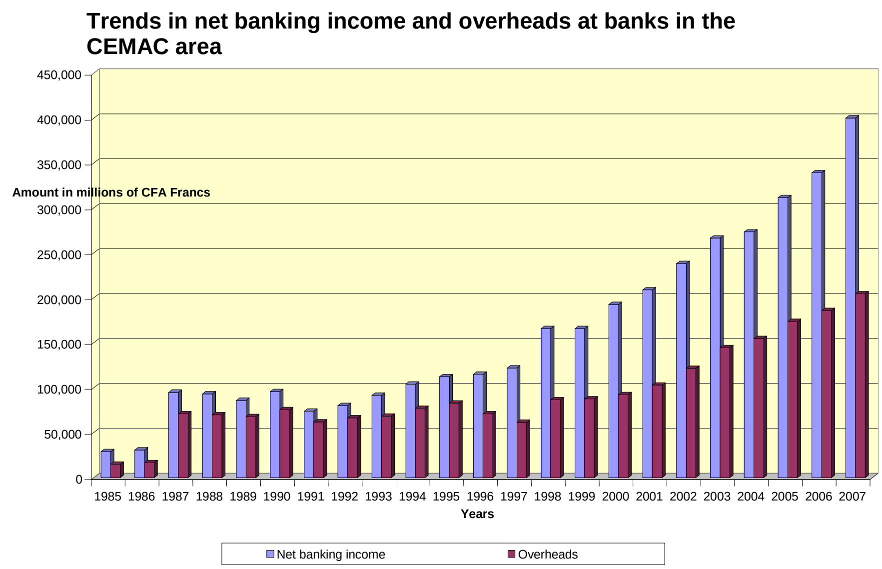


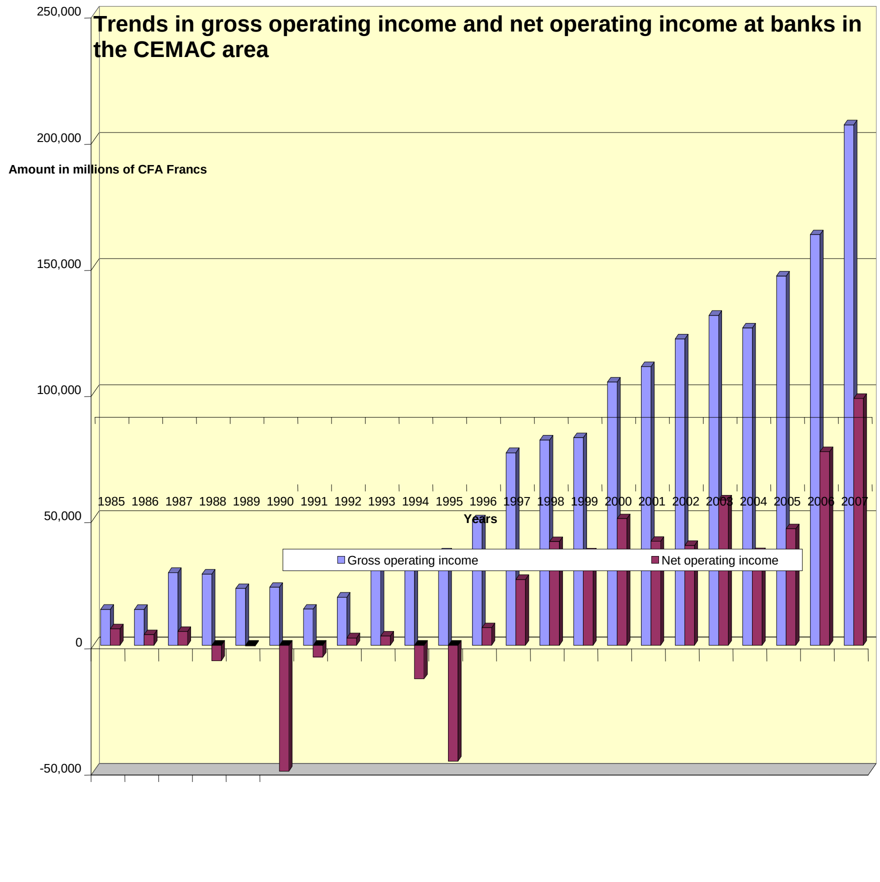
Trends in gross loans and bad debts of banks in the CEMAC area

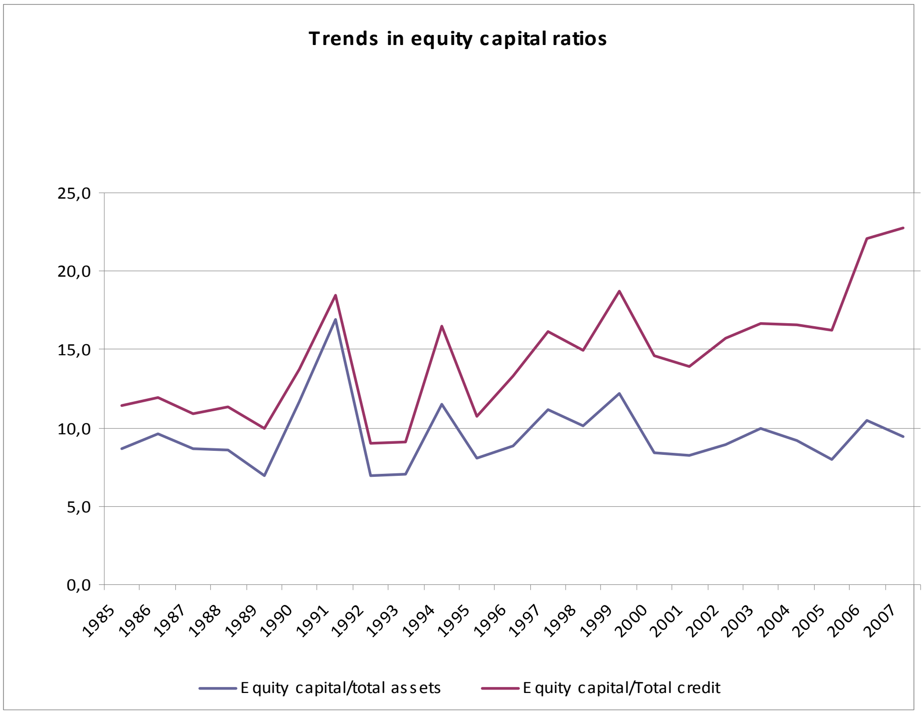


Trends in the cash balance at the banks in the CEMAC area

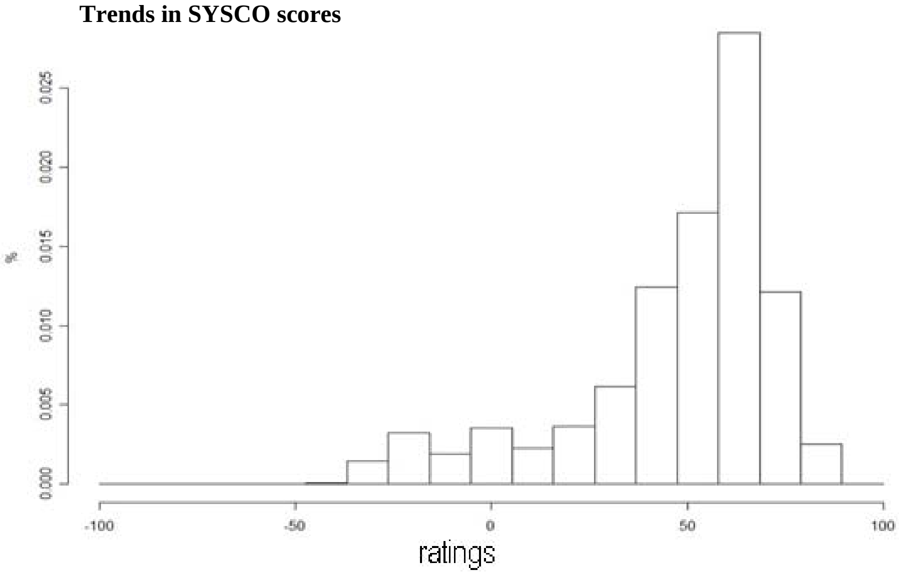



Trends in net banking income and overheads at banks in the CEMAC area
Amount in millions of CFA Francs
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
Years
Net banking income
Overheads


Trends in gross operating income and net operating income at banks in the CEMAC area
Amount in millions of CFA Francs
250,000
200,000
150,000
100,000
50,000
0
-50,000
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
Years
Gross operating income
Net operating income

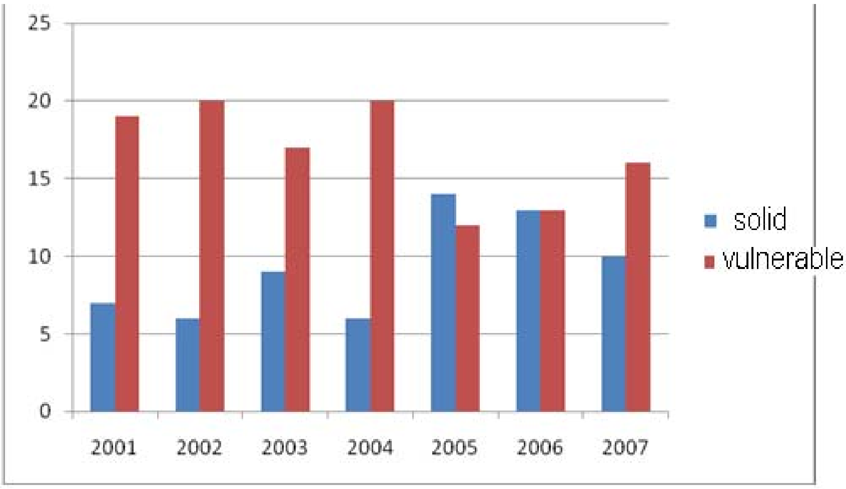


Trends in equity capital ratios
25,0
20,0
15,0
10,0
5,0
0,0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Equity capital/total assets
Equity capital/Total credit



Trends in SYSCO scores
%
0.000
0.005
0.010
0.015
0.020
0.025
-100
-50
0
50
100
ratings

Sample of banks



A1.1: Trends in the characteristics of solid banks

		Bad debts/ total loans	Fixed assets/ invested capital	Total loans/total assets	Investment loans/total loans	Housing credit/total loans	Equipment loans/ total loans	Consumer credit/total loans	Credit to insiders/ total loans	Overheads/ bank net profit	ROA	Liquidity ratio	Cash balance /total assets	Size of the bank	Size within the group	Interbank operations balance/ total balance sheet	Currency operations total balance sheet	Management score	Big risks concentration
2001	Mean	0.15	0.09	0.69	0.00	0.02	0.05	0.04	0.02	0.51	0.02	1.67	0.10	10.15	0.70	-0.02	0.00	1.00	0.19
	Median	0.13	0.03	0.58	0.00	0.01	0.02	0.03	0.01	0.53	0.01	1.84	0.14	9.83	1.00	-0.01	0.00	1.00	0.17
	Minimum	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.39	-0.21	7.73	0.12	-0.08	0.00	1.00	0.00
	Maximum	0.35	0.40	0.99	0.02	0.13	0.16	0.12	0.03	0.67	0.03	3.42	0.37	12.48	1.00	0.03	0.00	1.00	0.51
2002	Mean	0.24	0.09	0.67	0.02	0.03	0.06	0.03	0.03	0.44	0.03	6.00	0.11	10.22	0.87	-0.01	0.00	0.87	0.20
	Median	0.20	0.05	0.57	0.00	0.02	0.06	0.01	0.02	0.45	0.02	1.82	0.13	10.43	1.00	0.00	0.00	0.86	0.15
	Minimum	0.04	0.00	0.42	0.00	0.00	0.02	0.00	0.00	0.25	0.00	0.55	-0.04	7.54	0.58	-0.05	0.00	0.73	0.00
	Maximum	0.62	0.35	0.99	0.13	0.11	0.11	0.15	0.08	0.64	0.07	26.30	0.25	12.32	1.00	0.00	0.02	1.00	0.53
2003	Mean	0.20	0.07	0.65	0.04	0.03	0.05	0.04	0.03	3.24	-0.01	2.43	0.17	10.74	0.59	0.00	0.01	0.98	0.36
	Median	0.22	0.05	0.57	0.01	0.03	0.02	0.01	0.02	0.47	0.02	2.07	0.15	10.94	0.47	0.00	0.00	1.00	0.22
	Minimum	0.01	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.25	-0.27	1.12	-0.10	7.83	0.09	-0.02	0.00	0.87	0.00
	Maximum	0.35	0.16	1.08	0.13	0.11	0.22	0.18	0.12	25.52	0.06	4.00	0.60	12.49	1.00	0.00	0.09	1.00	1.00
2004	Mean	0.21	0.12	0.62	0.01	0.02	0.07	0.04	0.02	0.48	0.03	3.25	0.25	10.95	0.68	0.00	0.02	0.97	0.38
	Median	0.19	0.10	0.63	0.00	0.01	0.03	0.02	0.01	0.41	0.02	2.90	0.18	11.03	0.78	0.00	0.00	1.00	0.33
	Minimum	0.09	0.02	0.24	0.00	0.00	0.00	0.00	0.01	0.25	0.01	2.07	-0.03	9.77	0.18	-0.04	0.00	0.80	0.00
	Maximum	0.41	0.24	0.96	0.02	0.11	0.24	0.18	0.04	0.96	0.07	6.02	0.59	11.88	1.00	0.06	0.12	1.00	1.00
2005	Mean	0.15	0.20	0.53	0.06	0.03	0.09	0.05	0.02	0.57	0.02	2.47	0.33	11.39	0.56	0.00	0.15	0.88	0.26
	Median	0.15	0.15	0.49	0.01	0.02	0.09	0.02	0.01	0.53	0.02	2.74	0.31	11.44	0.50	0.00	0.00	0.99	0.17
	Minimum	0.00	0.02	0.16	0.00	0.00	0.00	0.00	0.00	0.26	-0.01	1.05	-0.06	9.39	0.11	-0.01	0.00	0.55	0.00
	Maximum	0.44	0.68	0.98	0.20	0.19	0.18	0.21	0.14	1.34	0.07	3.40	0.73	12.86	1.00	0.02	2.02	1.00	1.00
2006	Mean	0.13	0.28	0.50	0.07	0.03	0.11	0.07	0.02	0.62	0.03	2.73	0.35	11.53	0.64	0.01	0.23	0.95	0.28
	Median	0.16	0.13	0.46	0.02	0.01	0.10	0.03	0.01	0.56	0.02	2.70	0.36	11.30	0.55	0.00	0.00	1.00	0.16
	Minimum	0.01	0.02	0.18	0.00	0.00	0.01	0.00	0.00	0.24	0.00	1.45	-0.01	9.92	0.19	0.00	0.00	0.71	0.00
	Maximum	0.37	1.38	0.97	0.25	0.15	0.29	0.29	0.04	1.50	0.12	4.71	0.78	12.87	1.00	0.06	1.65	1.00	1.00
2007	Mean	0.12	0.15	0.47	0.05	0.03	0.15	0.10	0.02	0.98	0.02	2.25	0.38	11.56	0.58	0.01	0.09	0.92	0.20
	Median	0.16	0.12	0.44	0.01	0.02	0.17	0.04	0.01	0.55	0.02	2.48	0.36	11.61	0.46	0.00	0.00	1.00	0.17
	Minimum	0.01	0.05	0.13	0.00	0.00	0.01	0.01	0.01	0.24	-0.02	0.87	-0.08	10.02	0.13	-0.02	0.00	0.48	0.00
	Maximum	0.23	0.35	0.82	0.25	0.09	0.30	0.40	0.05	5.03	0.09	3.75	0.79	12.99	1.00	0.12	0.61	1.00	0.55

A1.2: Trends in the characteristics of vulnerable banks

		Bad debts/ total loans	Fixed assets/ invested capital	Total loans/ total assets	Investment loans/total loans	Housing credit/total loans	Equipment loans/total loans	Consumer credit/total loans	Credit to insiders/ total loans	Overheads/ bank net profit	ROA	Liquidity ratio	Cash balance /total assets	Size of the bank	Size within the group	Interbank operations balance/ total balance sheet	Currency transactions/ total balance sheet	Management score	Big risks concentration
2001	Mean	0.14	0.09	0.63	0.04	0.02	0.09	0.02	0.02	0.53	0.01	1.60	0.19	10.98	0.64	0.00	0.00	0.90	0.09
	Median	0.11	0.06	0.67	0.03	0.01	0.05	0.01	0.01	0.49	0.01	1.60	0.12	10.79	0.72	0.00	0.00	1.00	0.09
	Minimum	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.30	-0.04	0.40	-0.07	9.09	0.10	-0.15	0.00	0.40	0.00
	Maximum	0.38	0.47	1.11	0.17	0.08	0.27	0.11	0.10	1.07	0.05	3.19	0.61	12.61	1.00	0.19	0.04	1.00	0.25
2002	Mean	0.17	0.06	0.62	0.04	0.02	0.09	0.02	0.02	0.53	0.01	1.75	0.22	11.22	0.58	0.01	0.00	0.99	0.14
	Median	0.14	0.04	0.64	0.03	0.01	0.06	0.01	0.01	0.54	0.01	1.75	0.21	11.17	0.56	0.00	0.00	1.00	0.11
	Minimum	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	-0.04	0.74	-0.07	9.96	0.10	-0.06	0.00	0.92	0.00
	Maximum	0.46	0.16	1.09	0.14	0.11	0.27	0.14	0.08	0.77	0.05	3.11	0.66	12.66	1.00	0.09	0.02	1.00	0.50
2003	Mean	0.17	0.08	0.67	0.04	0.02	0.08	0.03	0.03	0.58	0.01	1.89	0.16	11.18	0.68	0.01	0.11	0.92	0.19
	Median	0.14	0.07	0.64	0.03	0.01	0.06	0.01	0.01	0.59	0.02	1.74	0.14	11.09	0.69	0.00	0.00	1.00	0.13
	Minimum	0.00	-0.20	0.27	0.00	0.00	0.00	0.00	0.00	0.36	-0.08	0.60	-0.19	9.73	0.11	-0.05	0.00	0.60	0.05
	Maximum	0.54	0.47	1.17	0.16	0.14	0.26	0.16	0.24	0.75	0.05	3.69	0.67	12.63	1.00	0.08	1.56	1.00	1.00
2004	Mean	0.17	-0.27	0.65	0.05	0.03	0.08	0.03	0.02	0.62	0.01	1.76	0.19	11.18	0.64	0.00	0.07	0.96	0.13
	Median	0.13	0.38	0.61	0.03	0.01	0.06	0.01	0.01	0.58	0.02	1.73	0.22	11.07	0.67	0.00	0.00	1.00	0.15
	Minimum	0.00	-11.67	0.34	0.00	0.00	0.00	0.00	0.00	0.39	-0.06	0.63	-0.16	8.64	0.09	-0.02	0.00	0.66	0.00
	Maximum	0.47	0.69	1.11	0.21	0.16	0.20	0.17	0.16	1.20	0.07	3.19	0.63	12.72	1.00	0.06	1.08	1.00	0.26
2005	Mean	0.18	0.08	0.65	0.06	0.02	0.07	0.02	0.01	0.59	0.02	1.92	0.23	11.26	0.74	0.00	0.01	0.94	0.12
	Median	0.12	0.38	0.62	0.02	0.01	0.06	0.01	0.01	0.60	0.01	1.81	0.23	11.11	0.85	0.00	0.00	1.00	0.11
	Minimum	0.04	-8.36	0.33	0.00	0.00	0.00	0.00	0.00	0.34	0.01	0.72	0.00	9.86	0.11	-0.03	0.00	0.53	0.00
	Maximum	0.43	4.82	1.04	0.26	0.07	0.22	0.09	0.02	0.73	0.04	3.21	0.66	12.77	1.00	0.01	0.08	1.00	0.24
2006	Mean	0.16	0.34	0.59	0.05	0.02	0.07	0.02	0.02	0.54	0.01	2.28	0.33	11.47	0.64	0.00	0.02	0.94	0.21
	Median	0.11	0.27	0.60	0.01	0.01	0.07	0.01	0.01	0.57	0.01	2.13	0.36	11.55	0.70	0.00	0.00	1.00	0.22
	Minimum	0.01	0.12	0.18	0.00	0.00	0.01	0.00	0.00	0.32	-0.02	1.20	-0.04	10.05	0.11	-0.03	0.00	0.67	0.06
	Maximum	0.40	0.90	1.00	0.20	0.06	0.17	0.11	0.16	0.82	0.04	3.63	0.71	13.00	1.00	0.00	0.13	1.00	0.59
2007	Mean	0.16	0.31	0.50	0.05	0.03	0.08	0.02	0.02	0.55	0.01	2.20	0.40	11.82	0.68	0.00	0.03	0.97	0.21
	Median	0.11	0.24	0.51	0.01	0.01	0.07	0.02	0.01	0.58	0.01	2.17	0.39	11.97	0.72	0.00	0.00	1.00	0.16
	Minimum	0.00	-0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.27	0.00	1.32	0.03	10.46	0.10	-0.02	0.00	0.62	0.06
	Maximum	0.58	1.01	0.85	0.17	0.13	0.21	0.12	0.07	0.86	0.04	3.45	0.92	13.28	1.00	0.02	0.35	1.00	0.89

A2 Trends in macroeconomic variables

A2.1 The REER

	Cameroon	Central African Republic	Congo	Gabon	Equatorial Guinea	Chad	CEMAC
2000	72.0	79.3	82.0	69.9	79.9	84.7	74.7
2001	72.7	80.4	80.7	70.1	83.6	92.1	75.8
2002	73.8	80.9	82.0	69.4	88.8	95.4	77.3
2003	75.1	83.4	84.4	71.3	98.1	93.9	79.6
2004	74.2	80.6	86.7	70.8	103.0	87.6	80.7
2005	72.5	81.5	86.9	69.4	105.4	90.9	80.9
2006	74.1	84.7	89.1	71.2	107.7	95.3	85.2
2007	74.4	84.9	90.9	74.5	114.5	87.1	88.2

Source: The Bank of Central African States (BEAC) annual reports, 2001 & 2007

A2.2: The real growth rate

	Cameroon	Central African Republic	Congo	Gabon	Equatorial Guinea	Chad	CEMAC
2000	4.7	1.3	7.6	-1.9	13.1	-0.1	3.2
2001	4.7	2.7	3.8	2.5	67.8	11.5	6.4
2002	4.0	0.3	4.6	-0.3	20.4	8.5	4.1
2003	4.0	-4.6	0.7	2.7	14.4	14.3	4.2
2004	3.7	3.5	3.7	1.4	32.6	33.7	6.6
2005	2.3	3.0	7.1	3.0	8.9	8.6	3.7
2007	3.9	3.6	-2.5	5.1	23.2	1.8	4.6

Source: The Bank of Central African States (BEAC) annual reports, 2001 & 2007

A2.3: Inflation

	Cameroon	Central African Republic	Congo	Gabon	Equatorial Guinea	Chad	CEMAC
2000	1.2	3.1	0.5	0.5	4.6	3.8	1.4
2001	4.5	3.8	0.8	2.1	8.8	12.4	4.4
2002	2.8	2.3	3.0	0.2	7.6	5.2	2.9
2003	0.6	4.2	1.7	2.3	7.3	-1.8	1.6
2004	0.3	-2.1	3.6	0.4	4.2	-5.3	0.6
2005	1.9	2.9	2.5	-0.2	5.0	7.9	2.9
2006	5.1	6.6	4.7	4.0	5.0	8.1	5.2
2007	1.1	1.0	2.5	4.8	5.5	-7.4	1.8

Source: The Bank of Central African States (BEAC) annual reports, 2001 & 2007

Matrix of the correlation of the model's variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Bad debts/total loans	1	1.0																				
Fixed assets/ invested capital	2	-.186	1.0																			
Total loans/total assets	3	.582	-.192	1.0																		
Investment loans/ total loans	4	-.182	0.0	-.251	1.0																	
Housing credit/total loans	5	0.1	0.0	0.0	0.1	1.0																
Equipment loans/ total loans	6	-.285	0.1	-.218	-0.1	0.0	1.0															
Consumer credit/ total loans	7	0.1	0.0	0.1	0.0	.335	.323	1.0														
Credit to insiders/ total loans	8	0.0	-0.1	0.0	.180	.172	0.0	0.0	1.0													
Overheads/bank net profit	9	0.1	0.0	0.0	-0.1	0.0	-0.1	0.1	0.0	1.0												
ROA	10	-.205	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	-.730	1.0											
Liquidity ratio	11	.219	0.1	-.249	0.0	0.1	0.0	0.0	-0.1	0.1	0.0	1.0										
Cash balance/total assets	12	-.308	0.1	-.804	.271	.165	0.1	-0.1	-0.1	-0.1	.175	.199	1.0									
Size of the bank	13	-.382	0.1	-.424	.503	0.1	.436	.243	0.1	-.265	.198	-0.1	.431	1.0								
Size of the bank within the group	14	.164	-0.1	.221	-.198	-0.1	0.0	0.0	.173	0.1	-.153	0.0	-.226	-.288	1.0							
Interbank operations balance/ total balance sheet	15	-.171	0.0	0.1	-0.1	-.147	0.1	0.0	-0.1	0.0	0.0	-0.1	-.196	-0.1	-0.1	1.0						
Currency transactions/total balance sheet	16	-.214	0.0	-0.1	-0.1	-0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	-0.1	0.0	1.0					
Management score	17	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	-0.1	0.0	0.1	1.0				
Big risks concentration	18	0.0	0.0	-.227	0.0	-.153	-.239	-.173	0.1	0.0	.314	.168	.193	-0.1	-.148	0.1	0.0	0.0	1.0			
GDP growth	19	0.0	0.0	-0.1	0.0	.174	-0.1	-.160	0.0	0.0	0.0	0.0	0.1	-0.1	-.199	-.264	-0.1	0.0	0.0	1.0		
Inflation	20	0.0	0.0	0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	-.179	0.0	0.0	0.0	0.0	1.0	
REER	21	-0.1	.159	-.217	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	.197	.153	-0.1	0.0	0.1	0.0	0.1	0.0	.169	1.0

Mean score for management quality according to nature of shareholding

Shareholding	Management quality
The State	0.85
Private foreign shareholders	0.93
Private domestic shareholders	0.97
Total	0.93

```
------------------------------------------------------------------------------

. gen fra10=(x27<10)

. xi : logit fra10 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6 v7 v8 v9 v10
network v11 v12 nrs hhi crpib infla ter i.country i.shareholding
> a
i.country         _Icountry_1-6        (naturally coded; _Icountry_1 omitted)
i.shareholding    _Ishareholding_1-3   (naturally coded; _Ishareholding_1 omitted)

Iteration 0:   log likelihood = -115.44953
Iteration 1:   log likelihood = -64.298435
Iteration 2:   log likelihood = -54.291591
Iteration 3:   log likelihood = -49.243898
Iteration 4:   log likelihood = -47.102002
Iteration 5:   log likelihood = -46.750719
Iteration 6:   log likelihood = -46.738811
Iteration 7:   log likelihood = -46.738793

Logistic regression                               Number of obs   =        175
                                                  LR chi2(34)     =     137.42
                                                  Prob > chi2     =     0.0000
Log likelihood = -46.738793                       Pseudo R2       =     0.5952

------------------------------------------------------------------------------
       fra10 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.221523    .642168     1.90   0.057    -.0371036    2.480149
          z2 |   .3485583   .6173076     0.56   0.572    -.8613423    1.558459
          z3 |   1.267269   .8478004     1.49   0.135    -.3943887    2.928928
          z4 |  -1.037246   .8396678    -1.24   0.217    -2.682965    .6084727
          z5 |  -.9077011   .7671769    -1.18   0.237     -2.41134    .5959381
          z6 |   .9240914   .9059258     1.02   0.308    -.8514906    2.699673
```

```
         v2 |  -.9194509   4.792344    -0.19   0.848    -10.31227    8.473371
         v3 |   -.198074   .5006878    -0.40   0.692    -1.179404     .783256
         v4 |  -1.227216   4.904655    -0.25   0.802    -10.84016    8.385731
        wc1 |  -10.37764    7.30006    -1.42   0.155    -24.68549    3.930215
        wc2 |  -25.96921   14.86183    -1.75   0.081    -55.09786    3.159445
        wc3 |  -2.462005   6.183827    -0.40   0.691    -14.58208    9.658074
        wc6 |  -.5960584   11.98755    -0.05   0.960    -24.09122     22.8991
         v5 |   30.63108   13.57497     2.26   0.024     4.024616    57.23754
         v6 |  -1.049741   .3729101    -2.81   0.005    -1.780632    -.318851
         v7 |  -108.9767   30.94357    -3.52   0.000    -169.6249   -48.32837
         v8 |  -2.050143   .7816534    -2.62   0.009    -3.582156   -.5181309
         v9 |    5.09718   3.686598     1.38   0.167     -2.12842    12.32278
        v10 |  -.3445328   .5060996    -0.68   0.496     -1.33647    .6474041
    network |   3.405712   1.492569     2.28   0.023     .4803315    6.331093
        v11 |  -2.252563   10.41994    -0.22   0.829    -22.67528    18.17015
        v12 |  -.1276956   1.454392    -0.09   0.930    -2.978251     2.72286
        nrs |  -6.792255    2.88534    -2.35   0.019    -12.44742   -1.137093
        hhi |   2.361988   2.231905     1.06   0.290    -2.012466    6.736442
      crpib |   .0340629   .0400288     0.85   0.395     -.044392    .1125178
      infla |   -.029254   .0676247    -0.43   0.665     -.161796    .1032881
        ter |  -4.011514   2.354767    -1.70   0.088    -8.626773     .603745
_Icountry_2 |  -1.898444   2.099771    -0.90   0.366    -6.013919    2.217031
_Icountry_3 |    4.27763   2.737135     1.56   0.118    -1.087056    9.642316
_Icountry_4 |  -4.373089   1.842425    -2.37   0.018    -7.984176   -.7620017
_Icountry_5 |   1.935767   2.336442     0.83   0.407    -2.643576    6.515109
_Icountry_6 |   2.861117   1.638239     1.75   0.081    -.3497733    6.072006
_Isharehold_2 |   6.574287    2.33509     2.82   0.005     1.997595    11.15098
_Isharehold_3 |   9.426526   2.948768     3.20   0.001     3.647046    15.20601
      _cons |   6.770778   8.098374     0.84   0.403    -9.101743     22.6433
------------------------------------------------------------------------------
 country ]
 shareholding]

Note: 4 failures and 0 successes completely determined.

. predict prdef10, pr
(7 missing values generated)

. gen pfra10=(prdef10>.35)

. tab fra10 pfra10 if prdef10!=.,row

+----------------+
| Key            |
|----------------|
```

```
|   frequency    |
| row percentage |
+----------------+

           |       pfra10
     fra10 |         0          1 |     Total
-----------+----------------------+----------
         0 |        96         14 |       110
           |     87.27      12.73 |    100.00
-----------+----------------------+----------
         1 |         7         58 |        65
           |     10.77      89.23 |    100.00
-----------+----------------------+----------
     Total |       103         72 |       175
           |     58.86      41.14 |    100.00


. gen fra11=(x27<11)

. xi : logit fra11 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6 v7 v8 v9 v10
network v11 v12 nrs hhi crpib infla ter i.country i.shareholding
> a
i.country          _Icountry_1-6         (naturally coded; _Icountry_1 omitted)
i.shareholding     _Ishareholding_1-3    (naturally coded; _Ishareholding_1 omitted)

Iteration 0:   log likelihood = -118.17062
Iteration 1:   log likelihood = -69.644178
Iteration 2:   log likelihood = -60.936729
Iteration 3:   log likelihood = -57.460823
Iteration 4:   log likelihood = -56.337229
Iteration 5:   log likelihood = -56.247175
Iteration 6:   log likelihood = -56.246171
Iteration 7:   log likelihood = -56.246171

Logistic regression                          Number of obs   =        175
                                             LR chi2(34)     =     123.85
                                             Prob > chi2     =     0.0000
Log likelihood = -56.246171                  Pseudo R2       =     0.5240

------------------------------------------------------------------------------
       fra11 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.726947   .5705752     3.03   0.002     .6086398    2.845254
          z2 |  -.2030983   .5307805    -0.38   0.702    -1.243409    .8372123
          z3 |   1.056917   .7047644     1.50   0.134     -.324396     2.43823
```

```
          z4 |  -.8017414   .7195307    -1.11   0.265    -2.211996    .6085129
          z5 |  -.6915152    .657827    -1.05   0.293    -1.980832     .597802
          z6 |   1.278212   .8914728     1.43   0.152    -.4690424    3.025467
          v2 |  -.8421254   4.301461    -0.20   0.845    -9.272835    7.588584
          v3 |   -.212991   .5286727    -0.40   0.687     -1.24917    .8231884
          v4 |  -1.038802   4.215752    -0.25   0.805    -9.301523    7.223919
         wc1 |  -5.733721   5.690408    -1.01   0.314    -16.88672    5.419273
         wc2 |  -26.94905   12.86693    -2.09   0.036    -52.16776   -1.730337
         wc3 |  -2.410695   5.718479    -0.42   0.673    -13.61871    8.797319
         wc6 |   .7538716   10.28746     0.07   0.942    -19.40917    20.91691
          v5 |   23.01283   11.61122     1.98   0.047     .2552505    45.77041
          v6 |  -.7806937    .348296    -2.24   0.025    -1.463341   -.0980461
          v7 |  -75.15299   24.91578    -3.02   0.003     -123.987   -26.31896
          v8 |  -1.512726   .6561627    -2.31   0.021    -2.798781    -.226671
          v9 |   4.200714   3.341073     1.26   0.209    -2.347668     10.7491
         v10 |  -.3520262    .489088    -0.72   0.472    -1.310621    .6065686
     network |   2.541145   1.307142     1.94   0.052    -.0208051    5.103096
         v11 |  -5.613333   10.16375    -0.55   0.581    -25.53391    14.30725
         v12 |  -.8662135   1.267974    -0.68   0.495    -3.351396    1.618969
         nrs |  -5.378687   2.571799    -2.09   0.036    -10.41932   -.3380527
         hhi |   1.524349    2.03393     0.75   0.454    -2.462081    5.510779
       crpib |   .0040383   .0362329     0.11   0.911     -.066977    .0750535
       infla |  -.1089475   .0644674    -1.69   0.091    -.2353014    .0174064
         ter |  -1.801155   1.858397    -0.97   0.332    -5.443546    1.841237
    _Ipays_2 |   -1.27125   1.847707    -0.69   0.491    -4.892689    2.350188
    _Ipays_3 |   3.256675   2.519695     1.29   0.196    -1.681836    8.195186
    _Ipays_4 |  -2.801571   1.523099    -1.84   0.066    -5.786789    .1836484
    _Ipays_5 |   2.429498    2.17619     1.12   0.264    -1.835755    6.694751
    _Ipays_6 |   1.677652   1.438931     1.17   0.244    -1.142601    4.497906
_Iactionna_2 |   4.232605   1.866218     2.27   0.023     .5748851    7.890326
_Iactionna_3 |   5.502608   2.275025     2.42   0.016      1.04364    9.961576
       _cons |   7.644595   7.503019     1.02   0.308    -7.061052    22.35024
------------------------------------------------------------------------------

note: 1 failure and 0 successes completely determined.

. predict prdef11, pr
(7 missing values generated)

. gen pfra11=(prdef11>.35)

. tab fra11 pfra11 if prdef11!=.,row

+----------------+
| Key            |
```

```
|----------------|
|   frequency    |
| row percentage |
+----------------+

           |       pfra11
     fra11 |         0          1 |     Total
-----------+----------------------+----------
         0 |        87         17 |       104
           |     83.65      16.35 |    100.00
-----------+----------------------+----------
         1 |        11         60 |        71
           |     15.49      84.51 |    100.00
-----------+----------------------+----------
     Total |        98         77 |       175
           |     56.00      44.00 |    100.00


. gen fra12=(x27<12)

. xi : logit fra12 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6 v7 v8 v9 v10
network v11 v12 nrs hhi crpib infla ter i.pays i.actionn
> a
i.pays            _Ipays_1-6          (naturally coded; _Ipays_1 omitted)
i.actionna        _Iactionna_1-3      (naturally coded; _Iactionna_1 omitted)

Iteration 0:   log likelihood = -121.22932
Iteration 1:   log likelihood =  -79.29735
Iteration 2:   log likelihood = -73.043417
Iteration 3:   log likelihood = -71.629766
Iteration 4:   log likelihood = -71.491031
Iteration 5:   log likelihood = -71.489113
Iteration 6:   log likelihood = -71.489113

Logistic regression                               Number of obs   =        175
                                                  LR chi2(34)     =      99.48
                                                  Prob > chi2     =     0.0000
Log likelihood = -71.489113                       Pseudo R2       =     0.4103

------------------------------------------------------------------------------
       fra12 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   .8752358   .4240871     2.06   0.039     .0440403    1.706431
          z2 |   .1536054   .4517077     0.34   0.734    -.7317255    1.038936
```

```
          z3 |   .5913898    .476345     1.24   0.214    -.3422292    1.525009
          z4 |   .0391352   .5358341     0.07   0.942     -1.01108    1.089351
          z5 |  -.3538399   .6107503    -0.58   0.562    -1.550888    .8432086
          z6 |   .8517483   .7742809     1.10   0.271    -.6658144    2.369311
          v2 |  -1.053829   3.831708    -0.28   0.783    -8.563838    6.456181
          v3 |  -.1216224   .4786827    -0.25   0.799    -1.059823    .8165784
          v4 |    .116502   3.701477     0.03   0.975     -7.13826    7.371264
         wc1 |  -8.161066    5.04844    -1.62   0.106    -18.05583    1.733694
         wc2 |  -8.703353    10.6477    -0.82   0.414    -29.57246    12.16576
         wc3 |  -4.569221   4.721053    -0.97   0.333    -13.82232    4.683873
         wc6 |   9.373287   8.093497     1.16   0.247    -6.489676    25.23625
          v5 |   22.21043   10.99073     2.02   0.043     .6689876    43.75188
          v6 |  -.5880978   .3594575    -1.64   0.102    -1.292621    .1164259
          v7 |  -52.52993   18.09629    -2.90   0.004      -87.998   -17.06186
          v8 |  -.9804902   .5047105    -1.94   0.052    -1.969705    .0087242
          v9 |   2.934362   2.968447     0.99   0.323    -2.883687     8.75241
         v10 |   .0580775   .4192913     0.14   0.890    -.7637185    .8798734
     network |   1.664567   1.082922     1.54   0.124    -.4579218    3.787056
         v11 |   3.284888     9.1616     0.36   0.720    -14.67152    21.24129
         v12 |  -2.024367   1.341417    -1.51   0.131    -4.653495    .6047619
         nrs |  -.4505392    2.03061    -0.22   0.824    -4.430462    3.529384
         hhi |   .2510677   1.614941     0.16   0.876    -2.914159    3.416294
       crpib |  -.0005602   .0331693    -0.02   0.987    -.0655708    .0644505
       infla |  -.0645921   .0547935    -1.18   0.238    -.1719854    .0428013
         ter |  -1.142854   1.658171    -0.69   0.491    -4.392811    2.107102
    _Ipays_2 |  -1.385903    1.52955    -0.91   0.365    -4.383767    1.611961
    _Ipays_3 |   1.181197   1.898659     0.62   0.534    -2.540105      4.9025
    _Ipays_4 |  -1.851844   1.136419    -1.63   0.103    -4.079184    .3754962
    _Ipays_5 |   .8628043   1.859474     0.46   0.643    -2.781698    4.507306
    _Ipays_6 |   .8445299   1.204187     0.70   0.483    -1.515633    3.204693
_Iactionna_2 |   2.993688   1.508886     1.98   0.047     .0363262    5.951049
_Iactionna_3 |   3.409702   1.831132     1.86   0.063    -.1792499    6.998654
       _cons |  -.7219927   6.431853    -0.11   0.911    -13.32819    11.88421
------------------------------------------------------------------------------

. predict prdef12, pr
(7 missing values generated)

. gen pfra12=(prdef12>.35)

. tab fra12 pfra12 if prdef12!=.,row

+----------------+
| Key            |
|----------------|
|   frequency    |
```

```
| row percentage |
+----------------+

           |       pfra12
     fra12 |         0          1 |     Total
-----------+----------------------+----------
         0 |        61         29 |        90
           |     67.78      32.22 |    100.00
-----------+----------------------+----------
         1 |        10         75 |        85
           |     11.76      88.24 |    100.00
-----------+----------------------+----------
     Total |        71        104 |       175
           |     40.57      59.43 |    100.00
```

```
. gen fra13=(x27<13)

. xi : logit fra13 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6 v7 v8 v9 v10
network v11 v12 nrs hhi crpib infla ter i.pays i.actionn
> a
i.pays            _Ipays_1-6          (naturally coded; _Ipays_1 omitted)
i.actionna        _Iactionna_1-3      (naturally coded; _Iactionna_1 omitted)

Iteration 0:   log likelihood = -120.65711
Iteration 1:   log likelihood = -70.083802
Iteration 2:   log likelihood = -60.034424
Iteration 3:   log likelihood = -56.640265
Iteration 4:   log likelihood = -55.904389
Iteration 5:   log likelihood = -55.851038
Iteration 6:   log likelihood = -55.850634
Iteration 7:   log likelihood = -55.850634

Logistic regression                               Number of obs   =        175
                                                  LR chi2(34)     =     129.61
                                                  Prob > chi2     =     0.0000
Log likelihood = -55.850634                       Pseudo R2       =     0.5371

------------------------------------------------------------------------------
       fra13 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.038647   .5228665     1.99   0.047     .0138479    2.063447
          z2 |   .7001387   .5382576     1.30   0.193    -.3548267    1.755104
          z3 |   .8565138   .5564103     1.54   0.124    -.2340305    1.947058
          z4 |   .6337441   .6478923     0.98   0.328    -.6361014     1.90359
```

```
          z5 |  -.0449017    .819495    -0.05   0.956    -1.651082    1.561279
          z6 |   .6502627   1.001796     0.65   0.516    -1.313222    2.613747
          v2 |   .1798146    4.88928     0.04   0.971    -9.402998    9.762627
          v3 |   .0834901   .6716038     0.12   0.901    -1.232829    1.399809
          v4 |   .1909983   4.490278     0.04   0.966    -8.609785    8.991782
         wc1 |  -9.907255   6.485404    -1.53   0.127    -22.61841    2.803903
         wc2 |  -11.93453   13.45166    -0.89   0.375    -38.29931    14.43025
         wc3 |  -9.120552   5.878137    -1.55   0.121    -20.64149    2.400386
         wc6 |   13.92163   10.91356     1.28   0.202    -7.468552    35.31181
          v5 |   34.07645   14.38782     2.37   0.018     5.876839    62.27606
          v6 |  -.7988688   .4449577    -1.80   0.073     -1.67097    .0732323
          v7 |  -76.30229   23.63384    -3.23   0.001    -122.6238   -29.98082
          v8 |  -1.202541   .6207489    -1.94   0.053    -2.419187    .0141044
          v9 |   3.802875   3.543063     1.07   0.283    -3.141401    10.74715
         v10 |   .6717315   .5057706     1.33   0.184    -.3195607    1.663024
     network |    1.19313   1.421608     0.84   0.401     -1.59317    3.979431
         v11 |   2.172523   10.47846     0.21   0.836    -18.36488    22.70992
         v12 |  -3.868262   1.942281    -1.99   0.046    -7.675062   -.0614615
         nrs |   .0087113   2.290354     0.00   0.997    -4.480301    4.497723
         hhi |   .3871221   1.895203     0.20   0.838    -3.327407    4.101651
       crpib |   .0118471   .0376788     0.31   0.753    -.0620019    .0856962
       infla |  -.0598112   .0619121    -0.97   0.334    -.1811567    .0615342
         ter |  -4.064189    2.02609    -2.01   0.045    -8.035252   -.0931256
    _Ipays_2 |  -1.788045   1.806451    -0.99   0.322    -5.328624    1.752535
    _Ipays_3 |   .2436288   2.300747     0.11   0.916    -4.265752     4.75301
    _Ipays_4 |  -1.885521   1.404817    -1.34   0.180    -4.638912    .8678696
    _Ipays_5 |  -.7164655   2.243233    -0.32   0.749    -5.113122    3.680191
    _Ipays_6 |   1.966589   1.597421     1.23   0.218    -1.164298    5.097476
_Iactionna_2 |   4.895141   1.905319     2.57   0.010     1.160784    8.629498
_Iactionna_3 |   4.595716   2.223925     2.07   0.039     .2369036    8.954528
       _cons |  -7.782859   7.899043    -0.99   0.324     -23.2647     7.69898
------------------------------------------------------------------------------

. predict prdef13, pr
(7 missing values generated)

. gen pfra13=(prdef13>.35)

. tab fra13 pfra13 if prdef13!=.,row

+----------------+
| Key            |
|----------------|
|   frequency    |
| row percentage |
```

```
+----------------+

          |       pfra13
    fra13 |         0          1 |     Total
-----------+----------------------+----------
        0 |        59         21 |        80
          |     73.75      26.25 |    100.00
-----------+----------------------+----------
        1 |         6         89 |        95
          |      6.32      93.68 |    100.00
-----------+----------------------+----------
    Total |        65        110 |       175
          |     37.14      62.86 |    100.00
```

```
. gen fra14=(x27<14)

. xi : logit fra14 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6 v7 v8 v9 v10
network v11 v12 nrs hhi crpib infla ter i.pays i.actionn
> a
i.pays            _Ipays_1-6          (naturally coded; _Ipays_1 omitted)
i.actionna        _Iactionna_1-3      (naturally coded; _Iactionna_1 omitted)

Iteration 0:   log likelihood = -117.77704
Iteration 1:   log likelihood = -71.240095
Iteration 2:   log likelihood = -63.227062
Iteration 3:   log likelihood = -60.861205
Iteration 4:   log likelihood = -60.505729
Iteration 5:   log likelihood = -60.493264
Iteration 6:   log likelihood = -60.493242

Logistic regression                               Number of obs   =        175
                                                  LR chi2(34)     =     114.57
                                                  Prob > chi2     =     0.0000
Log likelihood = -60.493242                       Pseudo R2       =     0.4864

------------------------------------------------------------------------------
       fra14 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |    1.82638   .5268125     3.47   0.001     .7938463    2.858913
          z2 |   .1559157   .5529167     0.28   0.778    -.9277812    1.239613
          z3 |    .509398   .5167679     0.99   0.324    -.5034484    1.522244
          z4 |   .3839627   .5896407     0.65   0.515    -.7717117    1.539637
          z5 |   .0221781   .7348771     0.03   0.976    -1.418154    1.462511
```

```
          z6 |   1.469653   .9402123     1.56   0.118    -.3731294    3.312435
          v2 |   4.115305   4.377709     0.94   0.347    -4.464847    12.69546
          v3 |   .1595203   .4993569     0.32   0.749    -.8192012    1.138242
          v4 |  -.4233437   3.942455    -0.11   0.914    -8.150414    7.303726
         wc1 |  -8.864005   5.566893    -1.59   0.111    -19.77491    2.046904
         wc2 |  -32.03122   13.03943    -2.46   0.014    -57.58804   -6.474398
         wc3 |  -3.696879   5.157714    -0.72   0.474    -13.80581    6.412055
         wc6 |   6.762603   8.541146     0.79   0.428    -9.977736    23.50294
          v5 |   23.94317   11.13544     2.15   0.032     2.118115    45.76823
          v6 |  -.6157407   .4266578    -1.44   0.149    -1.451975    .2204934
          v7 |  -49.12823   18.41716    -2.67   0.008     -85.2252   -13.03126
          v8 |   -.729467   .5357774    -1.36   0.173    -1.779571    .3206375
          v9 |   2.080209   3.227403     0.64   0.519    -4.245385    8.405802
         v10 |   .8837338    .502473     1.76   0.079    -.1010952    1.868563
     network |   1.675625   1.367341     1.23   0.220    -1.004313    4.355563
         v11 |   4.329971   10.77208     0.40   0.688    -16.78292    25.44286
         v12 |  -2.533755   1.497959    -1.69   0.091    -5.469701    .4021906
         nrs |  -.9025317    2.08479    -0.43   0.665    -4.988646    3.183582
         hhi |  -.4899444   1.453672    -0.34   0.736    -3.339088      2.3592
       crpib |  -.0105709   .0366834    -0.29   0.773     -.082469    .0613272
       infla |  -.0871523   .0646284    -1.35   0.177    -.2138216    .0395169
         ter |  -4.843916   1.997907    -2.42   0.015    -8.759741   -.9280901
    _Ipays_2 |  -1.069495   1.717185    -0.62   0.533    -4.435115    2.296126
    _Ipays_3 |   2.762153   2.202889     1.25   0.210    -1.555431    7.079737
    _Ipays_4 |   .3829336   1.111616     0.34   0.730    -1.795794    2.561661
    _Ipays_5 |   2.302954   2.219988     1.04   0.300    -2.048144    6.654051
    _Ipays_6 |   2.770812   1.502308     1.84   0.065    -.1736578    5.715281
_Iactionna_2 |   3.533495   1.676935     2.11   0.035     .2467632    6.820228
_Iactionna_3 |   2.775444   1.928636     1.44   0.150    -1.004614    6.555502
       _cons |  -9.454877   7.366565    -1.28   0.199    -23.89308    4.983326
------------------------------------------------------------------------------

. predict prdef14, pr
(7 missing values generated)

. gen pfra14=(prdef14>.35)

. tab fra14 pfra14 if prdef14!=.,row

+----------------+
| Key            |
|----------------|
|   frequency    |
| row percentage |
+----------------+
```

```
           |       pfra14
     fra14 |         0          1 |     Total
-----------+----------------------+----------
         0 |        45         25 |        70
           |     64.29      35.71 |    100.00
-----------+----------------------+----------
         1 |         6         99 |       105
           |      5.71      94.29 |    100.00
-----------+----------------------+----------
     Total |        51        124 |       175
           |     29.14      70.86 |    100.00
```

```
. gen fra15=(x27<15)

. xi : logit fra15 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6 v7 v8 v9 v10
network v11 v12 nrs hhi crpib infla ter i.actionna i.pay
> s
i.actionna        _Iactionna_1-3      (naturally coded; _Iactionna_1 omitted)
i.pays            _Ipays_1-6          (naturally coded; _Ipays_1 omitted)

Iteration 0:   log likelihood = -114.34818
Iteration 1:   log likelihood = -65.558253
Iteration 2:   log likelihood = -57.448488
Iteration 3:   log likelihood = -55.028434
Iteration 4:   log likelihood = -54.596666
Iteration 5:   log likelihood = -54.573448
Iteration 6:   log likelihood = -54.573343

Logistic regression                               Number of obs   =        175
                                                  LR chi2(34)     =     119.55
                                                  Prob > chi2     =     0.0000
Log likelihood = -54.573343                       Pseudo R2       =     0.5227

------------------------------------------------------------------------------
       fra15 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   2.458542   .6245969     3.94   0.000     1.234355     3.68273
          z2 |  -.4295361   .6804205    -0.63   0.528    -1.763136    .9040636
          z3 |   .4568946   .5554303     0.82   0.411    -.6317288    1.545518
          z4 |   .9046101   .6342312     1.43   0.154    -.3384603     2.14768
          z5 |   .5722209   .7676179     0.75   0.456    -.9322825    2.076724
          z6 |   1.320136    .934434     1.41   0.158    -.5113205    3.151593
```

```
          v2 |   3.331012   4.487354     0.74   0.458    -5.464041    12.12606
          v3 |   .2468271   .4584747     0.54   0.590    -.6517668    1.145421
          v4 |   2.108617    3.90927     0.54   0.590    -5.553412    9.770646
         wc1 |  -6.414913   5.644972    -1.14   0.256    -17.47885    4.649029
         wc2 |  -34.36691   14.05869    -2.44   0.015    -61.92143   -6.812394
         wc3 |   1.571845   5.613523     0.28   0.779    -9.430458    12.57415
         wc6 |   2.957474   8.494027     0.35   0.728    -13.69051    19.60546
          v5 |    18.2716   10.40274     1.76   0.079    -2.117407     38.6606
          v6 |  -.5320521   .4595941    -1.16   0.247     -1.43284    .3687357
          v7 |   -45.2675    20.6302    -2.19   0.028    -85.70195   -4.833043
          v8 |    -.53169   .5049155    -1.05   0.292    -1.521306    .4579262
          v9 |   .9735223   3.208365     0.30   0.762    -5.314758    7.261803
         v10 |    1.48642   .5452234     2.73   0.006     .4178013    2.555038
     network |   2.684027   1.587837     1.69   0.091    -.4280765     5.79613
         v11 |   7.694145   11.72793     0.66   0.512    -15.29217    30.68046
         v12 |  -1.853842    1.25212    -1.48   0.139    -4.307952    .6002672
         nrs |   -2.92961   2.394971    -1.22   0.221    -7.623667    1.764448
         hhi |  -.4443744   1.508899    -0.29   0.768    -3.401762    2.513013
       crpib |  -.0249408   .0406116    -0.61   0.539     -.104538    .0546565
       infla |  -.0798153   .0667777    -1.20   0.232    -.2106971    .0510665
         ter |  -5.868854   2.345271    -2.50   0.012     -10.4655   -1.272207
_Iactionna_2 |   2.711191   1.696776     1.60   0.110    -.6144285    6.036811
_Iactionna_3 |   1.513485   1.895556     0.80   0.425    -2.201736    5.228705
    _Ipays_2 |   -.426757   1.742984    -0.24   0.807    -3.842943    2.989429
    _Ipays_3 |   5.873603   2.511592     2.34   0.019     .9509731    10.79623
    _Ipays_4 |   1.173195    1.20717     0.97   0.331    -1.192814    3.539204
    _Ipays_5 |   5.507932   2.684921     2.05   0.040     .2455838    10.77028
    _Ipays_6 |   3.731022   1.690914     2.21   0.027      .416891    7.045153
       _cons |  -16.24746   7.855545    -2.07   0.039    -31.64404   -.8508743
------------------------------------------------------------------------------

. predict prdef15, pr
(7 missing values generated)

. gen pfra15=(prdef15>.35)

. tab fra15 pfra15 if prdef15!=.,row

+----------------+
| Key            |
|----------------|
|   frequency    |
| row percentage |
+----------------+
```

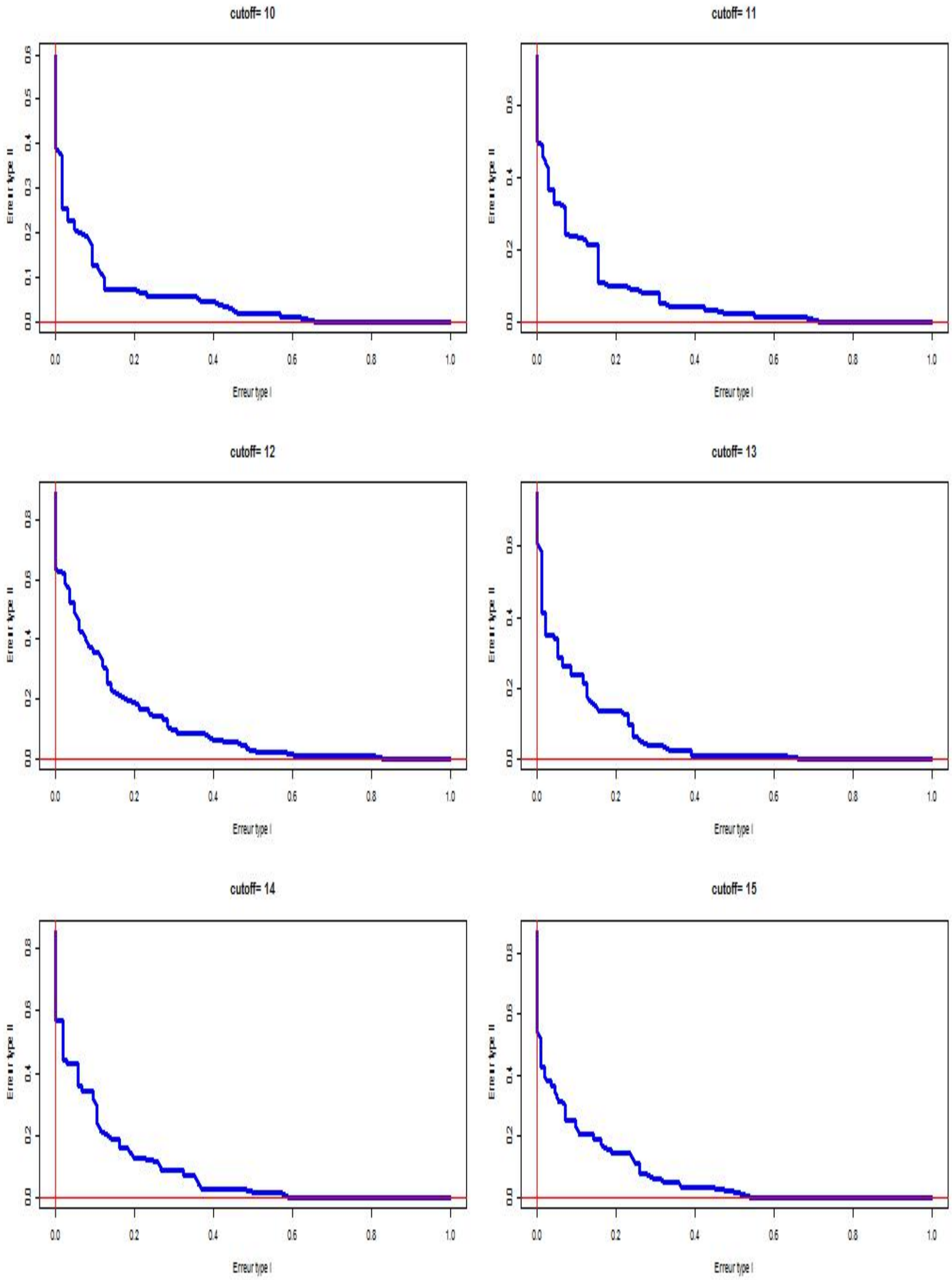
```
           |       pfra15
     fra15 |         0          1 |     Total
-----------+----------------------+----------
         0 |        40         23 |        63
           |     63.49      36.51 |    100.00
-----------+----------------------+----------
         1 |         5        107 |       112
           |      4.46      95.54 |    100.00
-----------+----------------------+----------
     Total |        45        130 |       175
           |     25.71      74.29 |    100.00
```

```
. stepwise, pr(.1) : logit fra15 z1 z2 z3 z4 z5 z6 v2 v3 v4 wc1 wc2 wc3 wc6 v5 v6
v7 v8 v9 v10 network v11 v12 nrs hhi crpib infla ter  _
> Iactionna_2 _Iactionna_3 _Ipays_2 _Ipays_3 _Ipays_4 _Ipays_5 _Ipays_6
                      begin with full model
p = 0.8066 >= 0.1000  removing _Ipays_2
p = 0.7904 >= 0.1000  removing v9
p = 0.7716 >= 0.1000  removing hhi
p = 0.7230 >= 0.1000  removing wc3
p = 0.6407 >= 0.1000  removing v4
p = 0.6334 >= 0.1000  removing v3
p = 0.5483 >= 0.1000  removing wc6
p = 0.5643 >= 0.1000  removing z2
p = 0.6213 >= 0.1000  removing crpib
p = 0.5565 >= 0.1000  removing z5
p = 0.3793 >= 0.1000  removing z3
p = 0.4627 >= 0.1000  removing _Iactionna_3
p = 0.3227 >= 0.1000  removing v6
p = 0.4641 >= 0.1000  removing _Ipays_4
p = 0.5276 >= 0.1000  removing v2
p = 0.3862 >= 0.1000  removing _Iactionna_2
p = 0.3037 >= 0.1000  removing v5
p = 0.2786 >= 0.1000  removing v11
p = 0.2947 >= 0.1000  removing nrs
p = 0.2620 >= 0.1000  removing network
p = 0.1947 >= 0.1000  removing wc1
p = 0.1959 >= 0.1000  removing _Ipays_3
p = 0.1241 >= 0.1000  removing infla

Logistic regression                               Number of obs   =        175
                                                  LR chi2(11)     =     100.99
                                                  Prob > chi2     =     0.0000
```

Log likelihood = -63.853554 Pseudo R2 = 0.4416

fra15	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
z1	1.57514	.3207628	4.91	0.000	.9464567	2.203824
ter	-3.899569	1.763074	-2.21	0.027	-7.355132	-.4440071
v8	-.7279454	.3288568	-2.21	0.027	-1.372493	-.0833978
z4	1.165295	.4145167	2.81	0.005	.3528568	1.977733
v10	1.076024	.2903769	3.71	0.000	.5068959	1.645152
z6	1.070995	.6507007	1.65	0.100	-.2043549	2.346345
v12	-2.339531	.9352763	-2.50	0.012	-4.172639	-.5064233
v7	-13.75301	7.366664	-1.87	0.062	-28.19141	.6853828
_Ipays_6	1.619741	.6674918	2.43	0.015	.311481	2.928001
_Ipays_5	2.107979	.9234899	2.28	0.022	.2979718	3.917986
wc2	-20.42918	8.251616	-2.48	0.013	-36.60205	-4.256311
_cons	-8.728371	3.090246	-2.82	0.005	-14.78514	-2.671601


cutoff= 10
cutoff= 11
cutoff= 12
cutoff= 13
cutoff= 14
cutoff= 15
Erreur type II
Erreur type I

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Abstract

Preventing bank failures is one of the fundamental concerns of decision-makers and it justifies the existence of banking supervision authorities. That is why bank supervisors have put in place measures aimed at enabling them to detect banks' difficulties early enough. The aim of the present study was to put forward an autoregressive logistic model of bank deterioration that could be used in countries in the CEMAC area as an early warning system (EWS). As explanatory variables, the model uses the financial variables that make up credit rating systems, the efficiency scores obtained using Data Envelopment Analysis as a proxy of management quality, shareholding, and the GDP growth rate; and as economic environment variables, it uses the inflation rate and the real effective exchange rate. The model also takes into account country effects. Although the simulations carried out in this study revealed that the model was less effective when used on out-of-sample data, the study still came up with a new typology of banks. For example, it found that a bank would be considered solid if the model had predicted it to be solid and its observed state was indeed solid at the predicted date. Such a typology makes it possible to use the results of the model by combining the model's prediction with the evolution of the situation of the bank in question. A refinement of this new typology can enable a better orientation of the bank supervision authority's prompt corrective action so as to prioritize the actions to be taken and to adapt them to the specific difficulties of each bank.

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