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A logit analysis of the experiences from the banking crisis

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ABSTRACT

Most existing early warning studies for the banking industry are based on U.S. data. The present paper considers the experiences made during the Norwegian banking crisis 1988-92. The performance of a set of possible early warning indicators are evaluated, both as independent indicators and as part of a simultaneous indicator system. The paper leads to recommendations for the future structure of early warning systems, specifically with reference to the Norwegian banking industry but with relevance even to the banking industries of other countries.

Contents

1. Introduction

Norges Bank and the Banking, Insurance and Securities Commission (BISC) have since 1989 and 1990, respectively, computed early warning indicators based on banks' interim reports. The purpose of these indicators is to identify potential problem banks, and to obtain a general picture of the health of the banking industry. Similar indicator systems are also used by Finnish and Swedish supervisory authorities as well as in a number of other European countries.

Supervisors' use of early warning systems for banks originated in the United States, and has been based on a substantial number of empirical studies appearing since the mid 1970's. The large number of units in the U.S. banking industry provides a unique database for investigating the characteristics of failing banks. A survey of this literature is given by Demirgüc-Kunt (1989). More recent contributions include Wang and Sauerhaft (1989), Williams et al. (1991), Cole (1993), and Hunter et al. (1993). Hooks (1992) provides a brief evaluation of early warning models.

Most of this literature, in particular the earliest studies, was initiated by U.S. supervisory authorities, for the practical purpose of establishing their own early warning systems. Such a system has normally been composed of five to ten indicators taken from the banks' balance sheets and income statements. The studies have aimed at identifying those indicators that most efficiently, and at an early stage, can discriminate between problem and non-problem banks, within a set of possible indicators taken on from the practical experiences of bank inspectors. The indicators selected by the analysis will naturally imply some (partial) theory of bank risk-taking, but no studies have contained explicit models of bank behaviour. That is presumably one reason why this literature remains somewhat away from the mainstream of banking research, with relatively few papers published in international journals.

Most European early warning systems are of more recent origin, and are to a large extent based on the U.S. experiences. The low number of bank failures in post-war Europe has given little reason to worry about the problem, and few observations on which to base

empirical research. However, following the recent experiences of open banking crises in the Scandinavian countries and more covert crises in several other European countries, the relaxed attitude of supervisors has changed. Also more observations of problem banks have become available, although not at a scale similar to the United States.

The Norwegian banking industry was particularly hard hit by the recent crisis, with 25 of the about 150 units in need of financial support during the years 1988-93. The present analysis is based on observations of these 25 banks some time prior to their appearance as problem banks, compared to observations of banks that never became problem banks. Section 2 below discusses the selection of indicators to be evaluated, with reference to the existing U.S. studies. Section 3 contains a methodological discussion of discriminant and qualitative response models. Section 4 briefly describes the Norwegian banking industry and the data used. Section 5 presents a preliminary partial analysis of the indicators. Section 6 proceeds to the simultaneous analysis by presenting the estimates of logit models for bank failure. Section 7 concludes with an appraisal of possible early warning systems for Norwegian banking.

2. Early warning indicators

We shall evaluate a set of indicators for the identification of potential problem banks. A bank will in the present study be considered to become a problem bank at the time when it seeks assistance from an insurance fund. That is an unambiguous definition of the concept, and it is similar to definitions employed in most U.S. studies.

The indicators should describe different aspects of the banks' conditions. To ensure coverage of the most important aspects, we follow the U.S. studies in organizing our indicators according to the CAMEL system of banking supervision. CAMEL is an acronym for (i) Capital adequacy, (ii) Asset quality, (iii) Management competence, (iv) Earnings, and (v) Liquidity, and represents a standard for summarizing on site inspection reports at U.S. banks. An inspection aims at evaluating the bank's standing on each of these points, based on an information set that is substantially richer than the balance sheet and the income

statement, on which early warning systems must be based. Early warning systems will thus not always be able to represent all aspects of the CAMEL system in a satisfactory fashion.

The selection of candidate indicators for the present study is based on experiences made in similar U.S. studies, which implies an assumption that the banking industries of the two countries are not basically different. Some indicators are also based on the practical experience from the bank surveillance undertaken in Norges Bank. Limitations on available data, in particular for the years prior to 1991, have made it impossible to include a number of indicators that might quite likely be relevant and which may in the future be computed from presently available data.

The indicators selected for evaluation are listed in table 1, with precise definitions of each concept given in the Appendix. The four indicators representing capital adequacy all measure asset-capital ratios. Such indicators have been found relevant by for instance Sinkey (1975) and Martin (1977). Our four indicators are quite similar, and they are naturally highly correlated, with correlation coefficients ranging from 0.57 to 0.94, confer the correlation matrix in table 2. Additional candidate indicators might have been based on the risk-weighted assets as defined by the BIS capital adequacy rules, but that variable can unfortunately only be computed as from September 1991.

The two indicators representing asset quality are both ratios between some risk asset category and a more comprehensive asset category. Similar indicators have been found relevant in U.S. studies, see for instance Martin (1977), Avery and Hanweck (1984), and Gajewski (1988). Notice that the two ratios, between commercial and industrial loans and total risk assets on the one hand, and between total risk assets and total sources of funds on the other hand, are negatively correlated, see table 2. The ratios thus describe different aspects of asset quality. Additional candidate indicators might have been based on the volume of non-performing loans, which has been reported in the official Bank Statistics since October 1988, but which, according to our Statistical Department, did not become reliable information until March 1992.

Management competence is hard to measure from the balance sheets or the income statements. We have selected two indicators that represent the risk-taking strategy of bank management, namely the bank's dependence on interest sensitive funding and the bank's rate of loan growth. Notice that these indicators are negatively correlated across our sample, contrary to the popular perception that increased lending before the banking crisis was primarily funded by interest sensitive funds. The first of the two candidates have been found relevant by for instance Barth et al. (1985) and Gajewski (1988), although Barth et al. took it to represent earnings rather than management competence. The second indicator has mostly not been included in U.S. studies.

Bank earnings will be represented by three candidate indicators, that are somewhat more focused on costs than is customary in the literature. The relative size of loss provisions is an obvious candidate, although not generally included in existing studies. The two ratios between expenditure and income concepts have been found relevant by for instance Sinkey (1975), although then interpreted as indicators of management competence. Notice that loss provisions are only weakly correlated with the level of operating costs, indicating that large losses do not systematically go with the inefficient operation of banks.

No indicators of bank liquidity will be evaluated. This choice is based on our a priori assumption that liquidity problems are symptoms of a crisis rather than the cause of it, and that such problems will normally only occur immediately before a crisis emerges. It is also hard to define a proper liquidity indicator, because a bank's ability to raise liquid funds will to a large extent depend on its credit standing. Furthermore, indicators of liquidity have rarely been found relevant in U.S. studies.

The CAMEL classification of the 11 candidate indicators is naturally somewhat arbitrary, and it does not always correspond to what one finds in other studies. But no firmly established classification exists in the literature. The important issue is whether the most relevant aspects of risk exposure have been covered. We believe that it has, possibly with an exception for a few indicators that could not be computed for the sample period, see above.

3. Methodology

Early studies in this field employed multiple discriminant analysis, see for instance Sinkey (1975). This is a classification technique that seeks to determine which other bank characteristics go most frequently with bank failure. A joint probability distribution of indicators and failure is assumed, with no theory of causation implied.

More recent studies have used qualitative response models, where the probability distribution of bank failure is assumed to depend on a set of independent indicators. Only the form of this conditional distribution need to be specified, and the assumptions made are thus less restrictive than in discriminant analysis. The qualitative response models are also more appealing because they present explicit hypotheses of causation.

We choose to assume that the conditional distribution for the event that a banks seeks financial assistance is logistic, implying what is in the econometrics textbooks known as a logit model. This model was first applied to early warning studies in banking by Martin (1977). The probability of no problems is assumed equal to:

$$P(y=1) = a_0 + \sum_i a_i * x_i \qquad (1)$$

where $y=1$ signifies a no-problem bank, and $y=0$ signifies the emergence of a bank problem. x_i represents indicator no. i. The parameters a_i will be estimated by the maximum likelihood routine of the RATS statistical programme.

4. The Norwegian banking industry

The Norwegian banking crisis surfaced in 1988, when one commercial and two savings banks had to ask their insurance funds for financial support. Commercial and savings banks have different legal status, the former being stock companies and the latter being self-owning institutions. Banks of the same size still tend to run approximately the same kind of activities. We shall thus consider them as one industry, and make comparisons across the two groups.

There were 173 Norwegian banks at the start of 1988. That number had been reduced to 134 five years later. The reduction was to some extent, but far from exclusively, caused by the banking crisis. Table 3 lists the 25 banks that needed outside financial assistance during the crisis, and indicates when they first appeared on the agenda of an insurance fund board meeting. This is the event which is taken to indicate that they became problem banks for the purpose of the analysis below. Notice that one of the problem banks, Norion, was established as late as 1986. We judged that to be too short a life for inclusion in the analysis. All the remaining 24 problem banks are included in at least part of the analysis below.

There was initially one insurance fund for commercial banks and one for savings banks. These funds are established by law, with compulsory membership, but they are organized by the banks themselves. A third insurance fund was established by the government in March 1991, when the two private funds were no longer able to meet the industry's capital needs. The government insurance fund operated at first through the private funds, but was later also given the authority to circumvent the private funds. The solution most frequently chosen by each of the three funds was merging a problem bank with a larger bank. Two small commercial banks have been liquidated, in 1989 and 1993. Only five of the largest banks have been allowed to continue as independent units after receiving guarantees or capital injections from the insurance funds.

The analysis will be based on the banks' statistical reports to the Banking, Insurance and Securities Commission. Balance sheets are reported monthly, whereas income statements were reported every four months from 1988 to 1991, and every three months in 1992. This will be the observation period and the periodicities used in the main part of the analysis, although annual data 1986-91 will also be considered. But analyses of the interim reports should be of greater interest, since the practical use of an early warning system must be based on these reports. The annual reports appear too infrequently, and with lags that are far longer than is acceptable for supervisory purposes.

5. Partial analysis of indicators

The mean values and the standard deviations of our eleven indicators are listed in table 4. We notice that the spread of values within the sample is quite substantial, even though we did omit a few obviously erroneous observations. Some extreme indicator values have still been retained, but none of them belong to the subset of problem banks. A few remaining data errors among the much more numerous observations of non-problem banks should be of little consequence for the results.

As a preliminary exercise we have computed average values of the indicators for the subset of banks that became problem banks within a certain time horizon, and compared them to the average values during the observation period for banks that never became problem banks. We computed t-statistics to test the null hypothesis that the two groups of banks have equal expected values of each indicator.

Table 5 is based on the annual reports 1986-91 and presents the differences between indicator values at 21 banks that became problem banks within one or two years and values at banks that never became problem banks. The corresponding t-statistics are given in parentheses. We notice that the last annual reports of problem banks are statistically significantly different from other banks at the conventional 5% test level for each of the four capital adequacy indicators, and each of the three earnings indicators. But in the preceding reports, taken between one and two years before the appearance of a problem, none of the differences computed are statistically significant.

One possible explanation for this negative result might be that systematic differences between small and large banks conceal differences between problem and non-problem banks of the same size. We therefore tried to omit the very largest and the very smallest banks from the sample, and then test for differences within the reduced sample, with 13 or 14 problem banks. That did not change the picture substantially, but the t-statistics did in general become somewhat higher, and the differences between problem and non-problem banks did now appear to be significant for CAP3, CAP4 and EAR1 more than one year before financial assistance was needed.

Similar partial tests based on the interim accounts 1988-92, with 18-24 problem banks depending on the length of the lead, are presented in table 6. The differences between problem and non-problem banks are in general more distinct the closer one is to the time when banks openly appear as problem banks. Less than four months before the event all our capital adequacy indicators, and all our three earnings indicators, exhibit significant differences between the two groups of banks. However, none of the asset quality or management competence indicators reveal significant differences. And with leads of more than 12 months no single indicator from any group reveals significant differences. This is in accordance with our findings from the annual data.

We repeated these tests on the reduced sample without the largest and smallest banks. As with annual data the t-statistics did become higher, but without changing the overall picture.

The partial analysis thus points to the capital adequacy and the earnings indicators as the most relevant for identifying problem banks. Should we require the inclusion of one indicator of asset quality, the share of commercial and industrial loans (ASS1) would seem preferable. Similarly, among the management competence indicators the extent of interest sensitive funding (MAN1) seems to be the most helpful one.

6. Logit models of problem banks

We now proceed to a simultaneous analysis by estimating the logit model introduced in section 3, with alternative lengths of the lead before problems emerge. We search in each case for the best model as defined by Akaike's Information Criterion, which penalizes over-parameterized models severely, see for instance Harvey (1981). The search process naturally implies that the conventional t-statistics reported for estimated coefficients should not be taken at face value. The preferred models should be taken to represent the most distinct patterns found in our current data sets, and the t-statistics should be interpreted as measures of how distinct these patterns are.

As in the partial analysis we start with the annual data 1986-91. We compare data from the last and the last but one annual report of problem banks to the reports from banks that never became problem banks, both within the full sample of banks, and within the reduced sample where the very smallest and the very largest banks were omitted. The best models based on these data sets are presented in table 7.

We notice that very few indicators are included in the preferred models. In three of the four cases capital adequacy is represented by CAP3, in the fourth case by CAP4. Both of these indicators measure capital adequacy relative to total loans, and not relative to total risk assets. The indicators for asset quality are never included, whereas each of the management competence indicators are included in two cases. Both the dependence on interest sensitive funding, and the growth rate of lending appear to be relevant information. Only one of the earnings indicators, namely loss provisions, are included, and in one of the four cases only.

The best models based on the interim reports 1988-92 and the full sample of banks with 18-24 problem banks included are presented in table 8A, whereas models based on the reduced sample with 10-16 problem banks are presented in table 8B. The problem banks are observed up to 20 months before financial support were needed. The models selected does not appear to depend systematically on the length of the time lead, or on the size of the sample.

The preferred models are now much richer than those based on the annual data, in the sense that many more indicators are included. All the four indicators of capital adequacy are included in at least one of the eight cases considered. But capital adequacy indicators measured relative to total loans are included more frequently, and with higher t-statistics, than indicators measuring capital relative to total risk assets. This is in accordance with the annual data analysis; it seems preferable to measure capital relative to total loans.

One asset quality indicator is included in seven of the eight cases, whereas the alternative indicator is never included. The preferred indicator is the ratio of commercial and

industrial loans to total risk assets. The ratio of risk assets to total sources of funds seems irrelevant, perhaps because the risk assets concept is too broadly defined.

The ratio of interest sensitive funding to total assets is included in five of the eight cases, whereas the other indicator of management competence is never included. This is a bit surprising, given the fact that loan growth was included in two of the very parsimonious models selected on annual data. The only explanation we can offer is that other new indicators included together span the ground previously covered by this growth indicator.

The ratio of operating expenses to total operating income is included in six of the eight cases. Notice that this earnings indicator has in other studies frequently been interpreted as an indicator of management competence, representing the efficiency of normal banking operations. Loss provisions are also found relevant in one case, but with a low t-statistic. This is perhaps surprising, given the fact that the need for financial assistance in most cases have arisen from heavy loan losses. But the loss provisions made in the interim reports often do not accurately represent the banks' situation. In particular, most of the loss provisions are made during the last months of the year, and very little is made during the preceding months.

Above only one model has been presented within each time lead, and each sample size. But we have also checked the alternative models that in many cases fitted the data nearly as well as those finally selected by the Akaike Criterion. These alternative models generally confirm the picture presented above, and provide little additional information.

Our conclusions correspond quite closely to the findings of the existing U.S. literature. The capital adequacy and the asset quality indicators selected above have been found relevant in a number of previous studies. Our management competence indicators are non-standard, but dependence on interest senstive funding have often been found relevant when classified as an earnings indicator, whereas loan growth rates have rarely been tested for. The earnings indicator selected above have also been found relevant in a number of studies, but has most often been taken to represent management competence. The overall impression is that the structure of banking problems in Norway is quite similar to the structures previously uncovered in the United States.

7. Early warning systems for Norwegian banking

The existing early warning systems, operated by Norges Bank and the BISC, are presented in table 9, together with what we would consider to our best recommendations from the present study. The two existing systems consist of seven and five indicators, respectively, whereas the present study indicates that fewer indicators would be sufficient. The best models based on annual reports (table 7) contain from one to three indicators, and those based on interim reports (tables 8A-B) contain from two to five indicators. In the table we have still listed four recommendations, one for each category of indicators.

The recommendations are primarily based on our analysis of the interim reports, since this is the data source used in the existing early warning systems. The annual reports appear too infrequently and with too long a lag to be satisfactory for early warning purposes. One should still keep an eye on indicators that appear as more relevant in the annual reports than in the interim reports, such as loss provisions and loan growth.

Norges Bank and the BISC measure capital adequacy relative to risk assets and total assets, respectively. Our recommendation would be to measure relative to total loans. However, it should be noted that the difference in predictive power to indicators based on risk assets is quite narrow. And while measuring relative to total assets was not tested for, it seem likely that this would perform quite well, too.

Norges Bank are using both of the indicators of asset quality tested in the present study. We found that only the relative importance of commercial and industrial loans was relevant. The BISC on the other hand has no indicator of asset quality, and thus not the one that generally does contribute significantly to the predictive power of our logit models.

The indicator for management competence used by Norges Bank is essentially the one recommended by the present study. The first of the BISC indicators also represent that same aspect of banking behaviour, although seen from a different angle. The second BISC indicator is last year's growth in lending, whereas we included three years' growth for testing in the present study. Preliminary analysis indicated that this was a better indicator than one

year's growth, but even three years' loan growth did not turn out to be of much relevance in our logit models.

Norges Bank has three and the BISC has two earnings indicators, whereas our analysis pointed to only one of them as essential for predicting bank failures. Notice in particular that both institutions use loss provisions, which we found to be unreliable when based on the interim reports. But we would still recommend keeping an eye on loss provisions at year end as an auxiliary indicator.

The two institutions use different weighting systems to produce a total index of banks' conditions. The logit model provides a third kind of weighting, but the large number of logit model versions estimated above differ substantially from each other, and do not give much guidance as to what weights should be used. We have thus no recommendations for new weightings of the selected indicators.

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Table 1: Early warning indicators to be evaluated within each CAMEL category

1. Capital adequacy

CAP1 = Risk assets / Equity capital
CAP2 = Risk assets / Capital
CAP3 = Total loans / Equity capital
CAP4 = Total loans / Capital

2. Asset quality

ASS1 = Commercial and industrial loans / Risk assets
ASS2 = Risk assets / Total sources of funds

3. Management competence

MAN1 = Interest sensitive funds / Total assets
MAN2 = Three year growth in total loans, in percents

4. Earnings

EAR1 = Loss provisions / Net operating income
EAR2 = Operating expenses / Total operating income
EAR3 = Non-interest operating expenses / Net operating income

5. Liquidity

(No indicators)

Table 2: Correlation matrix for early warning indicators, from the interim reports and the full sample of problem and non-problem banks.

	CAP1	CAP2	CAP3	CAP4	ASS1	ASS2	MAN1	MAN2	EAR1	EAR2	EAR3
CAP1	1.00										
CAP2	0.94	1.00									
CAP3	0.69	0.64	1.00								
CAP4	0.57	0.64	0.92	1.00							
ASS1	-0.21	-0.25	0.13	0.10	1.00						
ASS2	0.65	0.66	0.12	0.09	-0.35	1.00					
MAN1	0.37	0.28	0.40	0.26	0.09	0.06	1.00				
MAN2	-0.05	0.00	0.05	0.12	-0.04	0.06	-0.10	1.00			
EAR1	0.31	0.28	0.31	0.25	0.06	0.07	0.25	-0.14	1.00		
EAR2	0.27	0.29	0.41	0.44	0.13	0.13	0.06	0.26	0.19	1.00	
EAR3	0.25	0.29	0.37	0.42	0.07	0.10	0.05	0.11	0.56	0.79	1.00

Table 3: Banks assessed by the guarantee funds, organized according to the time of the initial assessment (four months periods)

1988	III	Sunnmørsbanken
		Sparebanken Nord
		Tromsø Sparebank
1989	I	Sparebanken Romsdal
		Spareskillingsbanken Trøndelag
	II	Varhaug Sparebank
	III	Norion Bank
		Flå Sparebank
1990	I	Sparebanken Moss-Hobøl
	II	Skiptvedt Sparebank
	III	Nordkapp Sparebank
		Sparebanken Nordland
		Hemnes Sparebank
		Fokus Bank
1991	I	Tysfjord Sparebank
		Nore Sparebank
		Halsa Sparebank
		Nittedal Sparebank
	II	Christiana Bank
	III	Sparebanken Rogaland
		Sparebanken Midt-Norge
		Den norske Bank
1992	II	Hof Sparebank
1993	I	Samvirkebanken
	II	Oslobanken

Table 4: Means and standard deviations of indicator values from the interim reports and the full sample of problem and non-problem banks.

Indicator	Mean value	Standard deviation
CAP1	7.49	3.55
CAP2	6.21	2.75
CAP3	10.50	3.64
CAP4	8.77	2.97
ASS1	0.43	0.15
ASS2	0.57	0.21
MAN1	0.14	0.14
MAN2	59.25	44.35
EAR1	0.10	0.22
EAR2	0.78	0.10
EAR3	0.47	0.19

Table 5: Partial evaluation of indicators based on the annual accounts: Average values at future problem banks minus average values at other banks. T-statistics in parentheses.*

	Less than one year's lead	1 - 2 years' lead
CAP1	17.78 (2.82)	4.12 (1.08)
CAP2	10.81 (2.67)	2.96 (1.03)
CAP3	23.28 (3.35)	5.84 (1.44)
CAP4	14.32 (3.02)	4.25 (1.31)
ASS1	0.11 (0.66)	0.08 (0.46)
ASS2	-0.003 (-0.01)	0.02 (0.08)
MAN1	0.16 (1.10)	0.11 (0.77)
MAN2	-5.41 (-0.13)	3.36 (0.08)
EAR1	0.87 (2.45)	0.20 (1.25)
EAR2	0.15 (1.84)	0.08 (0.97)
EAR3	0.29 (2.24)	0.08 (0.92)

* At the conventional 5% test level, the critical t-value for a one-sided test is 1.645.

Table 6: Partial evaluation of indicators based on interim accounts: Average values at future problem banks, with alternative leads*, minus average values at other banks. T-statistics in parentheses.

	0-4 months' lead	4-8 months' lead	12-16 months' lead	16-20 months' lead
CAP1	26.4913 (2.720)	8.196 (1.269)	3.464 (0.76)	4.442 (1.251)
CAP2	19.6554 (2.399)	5.199 (1.521)	2.346 (0.78)	2.934 (1.067)
CAP3	35.3718 (3.008)	10.491 (1.913)	4.562 (1.12)	5.213 (1.432)
CAP4	29.2138 (2.672)	6.592 (2.057)	2.992 (0.99)	3.375 (1.136)
ASS1	0.1239 (0.760)	0.128 (0.797)	0.110 (0.70)	0.075 (0.500)
ASS2	0.0070 (0.030)	-0.016 (-0.070)	0.040 (0.18)	0.064 (0.305)
MAN1	0.1539 (1.037)	0.155 (1.045)	0.152 (1.03)	0.117 (0.836)
MAN2	-9.2200 (-0.128)	-4.824 (-0.067)	3.095 (0.070)	4.771 (0.108)
EAR1	0.6333 (2.696)	0.286 (1.391)	0.247 (1.20)	0.030 (0.150)
EAR2	0.2027 (1.976)	0.069 (0.545)	0.103 (1.02)	0.093 (0.930)
EAR3	0.5219 (2.732)	0.199 (1.092)	0.187 (0.85)	0.078 (0.411)

* With quarterly data from 1991, we used 0-3 months, 6-9 months, 12-15 months and 18-21 months.

Table 7: Logit models for bank failures, based on the annual accounts of Norwegian banks 1987-91. Indicator values computed with leads of 0-2 years. T-statistics in parentheses.

Indicator	Full sample		Reduced sample	
	0-1 years	1-2 years	0-1 years	1-2 years
CAP1				
CAP2				
CAP3	-0.30 (-5.81)	-0.24 (-5.51)	-0.36 (-4.73)	
CAP4				-0.30 (-4.62)
ASS1				
ASS2				
MAN1	-2.76 (-1.35)		-4.82 (-1.68)	
MAN2			-0.01 (-2.21)	-0.01 (-2.03)
EAR1				-2.15 (-2.90)
EAR2				
EAR3				
Constant	8.85	6.60	12.37	8.58
Akaike's IC	91.90	156.82	47.14	93.70

Table 8A: Logit models for bank failures, based on four month interim accounts and the full sample of Norwegian banks 1988-92. Indicator values computed with a lead of 0-20 months. T-statistics in parentheses.

Indicator	Preferred model according to AIC, and given length of lead			
	0-4 months	4-8 months	12-16 months	16-20 months
CAP1		-0.08 (-1.99)		-0.23 (-4.39)
CAP2			-0.19 (-2.40)	
CAP3	-0.21 (-5.54)			
CAP4		-0.28 (-4.89)		
ASS1	-4.46 (-2.36)	-6.89 (-3.94)	-5.73 (-3.04)	-4.69 (-2.80)
ASS2				
MAN1		-2.86 (-1.77)	-2.94 (-1.88)	
MAN2				
EAR1		-0.44 (-1.28)		
EAR2	-15.53 (-5.69)		-7.27 (-3.01)	-5.01 (-2.01)
EAR3				
Constant	23.16	12.53	15.30	12.96
Akaike's IC	123.10	185.80	177.67	172.89

Table 8B: Logit models for bank failures, based on four month interim accounts and the reduced sample of Norwegian banks 1988-92. Indicator values computed with a lead of 0-20 months. T-statistics in parentheses.

Indicator	Preferred model according to AIC, and given length of lead			
	0-4 months	4-8 months	12-16 months	16-20 months
CAP1	-0.11 (-2.05)			
CAP2				
CAP3				-0.21 (-3.22)
CAP4	-0.30 (-3.94)	-0.40 (-6.54)	-0.17 (-2.15)	
ASS1	-3.74 (-1.35)	-3.93 (-2.09)	-3.71 (-1.65)	
ASS2				
MAN1	-2.99 (-1.04)	-4.50 (-2.55)	-4.72 (-2.40)	
MAN2				
EAR1				
EAR2	-13.66 (-3.96)		-9.11 (-3.26)	-8.44 (-2.75)
EAR3				
Constant	24.44	12.28	17.28	14.66
Akaike's IC	74.83	125.60	106.34	99.91

Table 9: Norwegian early warning indicators, and the recommendations from the present study.

1. Capital adequacy	
Norges Bank:	Equity capital / Risk assets
BISC:*	Equity capital / Total assets
Present study:	Total loans / Equity capital
2. Asset quality	
Norges Bank:	Commercial and industrial loans / Risk assets Risk assets / Total sources of funds
BISC:	(none)
Present study:	Commercial and industrial loans / Risk assets
3. Management competence	
Norges Bank:	Interest sensitive funds / Total sources of funds
BISC:	Total loans / Deposits from customers 12 months growth in lending
Present study:	Interest sensitive funds / Total assets
4. Earnings	
Norges Bank:	Loss provisions / Net operating income Operating expenses / Total operating income Non-interest operating expenses / Total operating income - interest costs
BISC:	Loss provisions / Total assets Operating expenses / Total operating income
Present study:	Operating expenses / Total operating income

* The Banking, Insurance and Securities Commission.

APPENDIX: DEFINITIONS OF VARIABLES

A. From the balance sheet (report 10)

Equity capital = Share capital + Own reserves = Codes 9.92-9.98 minus 2.59
Tier 2 capital = Subordinated debt + Provisions = Codes 7.77-9.91
Capital = Equity capital + Tier 2 capital

Commercial and industrial loans
= Codes 2.51-2.57, sectors 630, 710-790, 930-979
Total loans = Codes 2.51-2.57, all sectors
Bonds and certificates issued by non-government sectors
= Codes 1.33-1.36, 1.45, 3.61-3.62, 3.67-3.75
Risk assets = Total loans + Bonds and certificates issued by non-government sectors

Deposits from financial institutions
= Codes 6.22, sectors 150-250, 920-929
Money market loans = Codes 6.23.(15+35), 6.33
Borrowing from the central bank
= Codes 7.55.**.30
Interest sensitive funds = Deposits from financial institutions
+ Money market loans + Borrowing from the central bank
Total sources of funds = Total liabilities - Capital
= Codes 6.22-7.75

B. From the income statement (report 21)

Loss provisions = Codes 7.10.2.50.(11+12+30), 7.10.7.77.(15+20)
Interest expenses = Codes 4.10
Non-interest operating expenses (exclusive of depreciation allowances)
= Codes 5.50-5.55, 5.65
Operating expenses = Interest and non-interest operating expenses

Total operating income = Interest and fee income + Capital gains
= Codes 1.10-3.85
Net operating income = Total operating income - Interest expenses