

Uncertain Times and Early Predictions of Bank Failure
Financial Review Online Appendix

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Table 1

Candidate variables for the bank failure model specification

Variable	Description	Call Report Series
Loans past due 90+ days	Loans past due 90 days or more and still accruing interest divided by assets	RCFD1407
Nonaccrual loans	Loans in nonaccrual status divided by assets	RCFD1403
Foreclosed real estate	Foreclosed real estate divided by assets	RCFD2150
Equity	Equity divided by assets	RCFD3210
Net income	Income before income taxes and discontinued operations divided by assets	RIAD4301
Securities	Available for sale and held to maturity securities divided by assets	RCFD1754 + RCFD1773
Loan loss reserves	Allowance for loan and lease losses divided by assets	RCFD3123
Jumbo CDs	CD greater than or equal to \$100,000 divided by assets	RCON2604
Cash	Cash and balances due from depository institutions divided by assets	RCFD0010
Demand deposits	Total demand deposits divided by assets	RCON2210
Federal funds purchased	Federal funds purchased divided by assets	RCONB993 + RCONB995
Volatile liability expense	Interest paid on federal funds purchased and large CDS divided by assets	RIAD4190 + RIADA517
Charge-offs	Charge-offs divided by assets	RIAD4635
Brokered deposits	Indicator variable equal to 1 if the ratio of brokered deposits to total assets is greater than 1% and equal to 0 otherwise	RCON2365
Non-interest expense	Non-interest expense divided by assets	RIAD4093
Insider loans	Loans to insiders divided by assets	RIAD4093
Dividends	Dividends divided by assets	RCFD6164
Age	Age of the bank in years	RSSD9950
Size	Natural log of assets	RCFD2170
Provisions for loan losses	Provisions for loan and lease losses divided by assets	RIAD4230
C & I loans	Commercial and industrial loans divided by assets	RCFD1766
Commercial real estate	Commercial real estate loans divided by assets	RCON1480
Consumer loans	Consumer loans loans divided by assets	RCFD1975
Agriculture loans	Agriculture loans loans divided by assets	RCFD1590
Federal funds sold	Federal funds sold loans divided by assets	RCONB987 + RCONB989

Series are divided by total assets (RCFD2170) where noted. Prior to 2002 federal funds purchased (sold) were reported in series RCON2800 (RCON1350). Volatile liability expense consists the sum of (RIAD4190, RIAD4174) prior to 1997, and securities were the sum of (RCFD0390, RCFD2146) prior to 1994.

Table 2

Logit model of bank failure (1985, 1986)

The logit model uses a cross-section of year-end bank data from the year indicated to predict failures in the year ahead. BMA estimates reported include the posterior mean (Coef), standard deviation (SE), and effect probabilities (PEP) of the variables averaged over. The stepwise model is selected based on Akaike's information criterion (AIC).

	1985						1986					
	BMA Model			Stepwise Model			BMA Model			Stepwise Model		
	Coef	SE	PEP	Coef	SE	P-value	Coef	SE	PEP	Coef	SE	P-value
Constant	1.098	1.394	100	0.563	1.438	0.696	7.239	1.380	100	6.891	1.515	0.000
Loans past due 90+ days	24.251	4.795	100	20.772	4.802	0.000	30.589	4.692	100	27.191	4.630	0.000
Nonaccrual loans	19.522	3.541	100	19.818	3.510	0.000	30.990	3.250	100	25.941	3.382	0.000
Foreclosed real estate	2.437	5.601	17.9	11.225	4.824	0.020	0.230	1.539	2.6	9.239	4.130	0.025
Equity	-54.431	4.799	100	-52.480	4.972	0.000	-42.903	4.073	100	-40.570	4.582	0.000
Net income	-	-	-	-	-	-	-	-	-	-	-	-
Securities	-0.128	0.664	4.2	-	-	-	-5.105	1.172	100	-5.180	1.172	0.000
Loan loss reserves	-3.445	8.700	15.6	-25.174	7.948	0.002	-41.998	8.560	100	-39.820	8.499	0.000
Jumbo CDs	0.803	1.349	29.1	2.539	0.997	0.011	2.802	1.181	90.8	3.151	0.904	0.000
Cash	-	-	-	-	-	-	-2.016	2.441	45.6	-2.595	1.573	0.099
Demand deposits	-	-	-	-	-	-	-	-	-	-	-	-
Federal funds purchased	-	-	-	-	-	-	-	-	-	-	-	-
Volatile liability expense	-	-	-	1.611	0.786	0.040	-	-	-	-	-	-
Charge-offs	0.120	1.149	1.3	10.425	4.338	0.016	0.577	2.388	6.6	9.887	3.983	0.013
Brokered deposits	0.051	0.225	5.6	0.558	0.372	0.133	-	-	-	-	-	-
Non-interest expense	-	-	-	-	-	-	-	-	-	-10.826	6.220	0.082
Insider loans	1.514	3.156	21.4	7.244	2.405	0.003	2.398	5.038	20.7	10.830	3.921	0.006
Dividends	-	-	-	-	-	-	-	-	-	-	-	-
Age	-	-	-	-	-	-	0.000	0.001	1.9	0.007	0.004	0.045
Size	-0.461	0.124	100	-0.474	0.125	0.000	-0.759	0.118	100	-0.807	0.124	0.000
Provisions for loan losses	-	-	-	-	-	-	-	-	-	-	-	-
C & I loans	6.492	1.204	100	5.990	1.106	0.000	0.079	0.442	3.7	2.761	1.015	0.007
Consumer loans	-	-	-	-	-	-	-	-	-	-	-	-
Commercial real estate	2.879	3.699	41.3	6.150	2.223	0.006	-8.011	2.078	100	-6.910	2.146	0.001
Agriculture loans	7.143	1.125	100	7.946	1.025	0.000	-	-	-	-	-	-
Federal funds sold	-1.089	2.366	20.1	-4.277	2.035	0.036	-7.343	1.726	100	-6.660	1.788	0.000
Observations	13994						13756					
Number of Models	37						12					
PMP of best model	0.14						0.32					

Table 2 (continued)

Logit model of bank failure (1987, 1988)

The logit model uses a cross-section of year-end bank data from the year indicated to predict failures in the year ahead. BMA estimates reported include the posterior mean (Coef), standard deviation (SE), and effect probabilities (PEP) of the variables averaged over. The stepwise model is selected based on Akaike's information criterion (AIC).

	1987						1988					
	BMA Model			Stepwise Model			BMA Model			Stepwise Model		
	Coef	SE	PEP	Coef	SE	P-value	Coef	SE	PEP	Coef	SE	P-value
Constant	-1.771	0.639	100	-1.558	1.178	0.186	-0.163	0.958	100	2.155	1.204	0.073
Loans past due 90+ days	32.030	5.623	100	27.620	5.765	0.000	0.377	2.443	2.8	12.229	5.960	0.040
Nonaccrual loans	20.191	3.733	100	18.792	3.823	0.000	20.192	4.262	100	20.959	4.105	0.000
Foreclosed real estate	13.436	3.053	100	12.881	3.023	0.000	13.126	4.014	97.9	16.649	3.485	0.000
Equity	-34.657	3.940	100	-31.981	3.959	0.000	-55.313	4.975	100	-53.953	4.642	0.000
Net income	-	-	-	-	-	-	-1.403	5.097	7.6	-	-	-
Securities	-3.833	1.020	100	-3.537	1.086	0.001	-5.781	1.101	100	-5.915	1.146	0.000
Loan loss reserves	-47.252	9.060	100	-46.879	9.074	0.000	-42.000	16.225	95.3	-52.149	12.002	0.000
Jumbo CDs	-	-	-	1.920	0.858	0.025	4.594	1.004	100	5.374	1.068	0.000
Cash	-2.150	2.873	41.1	-5.001	2.002	0.013	-	-	-	-	-	-
Demand deposits	-4.577	2.369	85.8	-4.909	1.778	0.006	-2.523	2.785	49.8	-3.536	1.801	0.050
Federal funds purchased	-	-	-	-	-	-	-	-	-	-	-	-
Volatile liability expense	-	-	-	-	-	-	0.066	0.495	1.9	3.861	0.906	0.000
Charge-offs	-	-	-	-	-	-	0.265	1.793	2.6	-	-	-
Brokered deposits	-	-	-	-	-	-	-	-	-	-	-	-
Non-interest expense	-	-	-	9.074	4.752	0.056	-2.431	7.107	12	-11.343	6.649	0.088
Insider loans	1.962	4.704	16.6	9.807	4.236	0.021	-	-	-	-	-	-
Dividends	-3.042	16.173	4.4	-73.804	38.221	0.053	-323.787	95.371	100	-298.366	95.679	0.002
Age	-	-	-	0.010	0.003	0.002	0.000	0.002	3.9	0.007	0.003	0.037
Size	-	-	-	-0.129	0.090	0.152	-0.015	0.061	6.7	-0.287	0.102	0.005
Provisions for loan losses	24.801	4.361	100	22.917	4.488	0.000	6.913	9.383	39.1	16.650	5.989	0.005
C & I loans	0.053	0.368	2.5	1.751	1.071	0.102	-	-	-	-	-	-
Consumer loans	-	-	-	-	-	-	-	-	-	-	-	-
Commercial real estate	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture loans	-	-	-	-	-	-	-	-	-	-	-	-
Federal funds sold	4.847	0.683	100	5.098	0.751	0.000	0.312	0.881	12.7	2.494	0.964	0.010
Observations	13286						12804					
Number of Models	9						29					
PMP of best model	0.39						0.16					

Table 2 (continued)

Logit model of bank failure (1989, 1990)

The logit model uses a cross-section of year-end bank data from the year indicated to predict failures in the year ahead. BMA estimates reported include the posterior mean (Coef), standard deviation (SE), and effect probabilities (PEP) of the variables averaged over. The stepwise model is selected based on Akaike's information criterion (AIC).

	1989						1990					
	BMA Model			Stepwise Model			BMA Model			Stepwise Model		
	Coef	SE	PEP	Coef	SE	P-value	Coef	SE	PEP	Coef	SE	P-value
Constant	-1.492	0.685	100	1.607	1.198	0.180	0.936	0.966	100	2.472	1.583	0.119
Loans past due 90+ days	22.876	16.265	72.8	30.187	9.659	0.002	0.704	4.290	3.1	-	-	-
Nonaccrual loans	-	-	-	15.665	5.060	0.002	1.600	4.172	14.5	15.134	5.342	0.005
Foreclosed real estate	14.939	3.593	100	12.758	3.760	0.001	1.660	4.294	14.8	9.348	4.585	0.041
Equity	-70.031	4.856	100	-71.566	5.398	0.000	-90.224	7.292	100	-86.062	6.756	0.000
Net income	-18.002	4.327	98.4	-15.001	4.495	0.001	-3.407	6.362	25	-	-	-
Securities	-0.032	0.286	1.5	-	-	-	-4.684	1.780	94.5	-2.326	1.557	0.135
Loan loss reserves	-	-	-	-30.104	13.000	0.021	-0.609	4.638	2	-27.795	13.059	0.033
Jumbo CDs	0.150	0.765	4.3	2.662	1.501	0.076	-	-	-	-4.658	2.221	0.036
Cash	-	-	-	-	-	-	-1.111	3.037	13.7	-5.105	3.704	0.168
Demand deposits	-	-	-	-	-	-	-2.470	3.304	40.3	-7.866	2.520	0.002
Federal funds purchased	-	-	-	-	-	-	-	-	-	-	-	-
Volatile liability expense	-	-	-	-	-	-	-	-	-	-	-	-
Charge-offs	-	-	-	-	-	-	-	-	-	-	-	-
Brokered deposits	-	-	-	-	-	-	1.513	0.332	100	1.454	0.357	0.000
Non-interest expense	0.270	2.178	1.6	-	-	-	1.191	4.874	6.3	14.432	7.780	0.064
Insider loans	-	-	-	-	-	-	-	-	-	-	-	-
Dividends	-	-	-	-	-	-	-	-	-	-	-	-
Age	0.000	0.002	3.5	-	-	-	-	-	-	-	-	-
Size	-0.013	0.053	6.6	-0.349	0.107	0.001	-0.005	0.036	2.6	-0.243	0.115	0.034
Provisions for loan losses	0.291	2.382	1.6	-	-	-	-	-	-	-	-	-
C & I loans	2.204	2.109	56.9	3.600	1.256	0.004	0.027	0.300	1	5.449	1.592	0.001
Consumer loans	-	-	-	-	-	-	-	-	-	2.311	1.263	0.067
Commercial real estate	0.056	0.480	1.7	3.602	1.779	0.043	0.040	0.400	1.2	3.720	1.851	0.045
Agriculture loans	-0.106	0.762	2.4	-4.795	2.591	0.064	-	-	-	-	-	-
Federal funds sold	-	-	-	-	-	-	-0.044	0.461	1.1	-	-	-
Observations	12917						12589					
Number of Models	12						26					
PMP of best model	0.30						0.18					

Table 2 (continued)

Logit model of bank failure (1991, 1992)

The logit model uses a cross-section of year-end bank data from the year indicated to predict failures in the year ahead. BMA estimates reported include the posterior mean (Coef), standard deviation (SE), and effect probabilities (PEP) of the variables averaged over. The stepwise model is selected based on Akaike's information criterion (AIC).

	1991						1992					
	BMA Model			Stepwise Model			BMA Model			Stepwise Model		
	Coef	SE	PEP	Coef	SE	P-value	Coef	SE	PEP	Coef	SE	P-value
Constant	0.139	0.638	100	-4.122	1.454	0.005	4.016	2.959	100	4.587	2.314	0.047
Loans past due 90+ days	-	-	-	-	-	-	-	-	-	-	-	-
Nonaccrual loans	26.614	7.608	100	29.258	6.703	0.000	27.807	6.294	100	19.912	6.228	0.001
Foreclosed real estate	-	-	-	-	-	-	23.832	5.388	100	16.440	5.672	0.004
Equity	-85.360	7.109	100	-92.119	7.198	0.000	-81.600	9.344	100	-86.225	10.504	0.000
Net income	-	-	-	-10.390	4.522	0.022	-4.226	6.866	28	-32.442	11.709	0.006
Securities	0.021	0.244	0.9	3.000	1.136	0.008	-0.511	1.640	10.5	-4.209	2.012	0.036
Loan loss reserves	-22.843	24.459	51.5	-56.348	15.203	0.000	-	-	-	-	-	-
Jumbo CDs	1.993	2.617	40	4.920	1.589	0.002	10.553	3.184	96.9	12.191	2.971	0.000
Cash	-0.089	1.017	0.9	-5.627	4.090	0.169	-	-	-	-	-	-
Demand deposits	-12.996	2.783	100	-12.353	2.635	0.000	-	-	-	-	-	-
Federal funds purchased	-	-	-	-19.394	9.006	0.031	-	-	-	-	-	-
Volatile liability expense	-	-	-	2.768	1.058	0.009	-	-	-	8.972	4.922	0.068
Charge-offs	-	-	-	-	-	-	-	-	-	-39.220	17.869	0.028
Brokered deposits	-	-	-	-	-	-	-	-	-	-	-	-
Non-interest expense	17.110	4.361	99.1	18.779	4.064	0.000	-	-	-	-	-	-
Insider loans	-	-	-	-	-	-	-	-	-	-	-	-
Dividends	-	-	-	-	-	-	-	-	-	-	-	-
Age	-	-	-	-	-	-	-	-	-	-	-	-
Size	0.003	0.026	1.7	0.314	0.109	0.004	-0.598	0.257	91.6	-0.536	0.192	0.005
Provisions for loan losses	-	-	-	-	-	-	-	-	-	-	-	-
C & I loans	2.793	2.745	55.5	5.911	1.530	0.000	-	-	-	-	-	-
Consumer loans	-	-	-	-	-	-	-	-	-	-	-	-
Commercial real estate	-	-	-	-	-	-	0.154	0.922	3.3	-	-	-
Agriculture loans	-4.187	5.818	40.2	-7.247	4.386	0.098	-	-	-	-	-	-
Federal funds sold	2.725	2.309	62.6	5.400	1.217	0.000	-0.713	2.008	13.5	-5.091	2.313	0.028
Observations	12160						11772					
Number of Models	28						9					
PMP of best model	0.16						0.44					

Table 3.

Cox proportional hazards model estimates of bank failure - S & L Crisis

Cox model estimates of the time to bank failure in days between 2/1/1986 and 2/1/1994. The control variables are measured using year-end bank data from 1985. BMA estimates reported include the posterior mean (Coef), standard deviation (SE), and effect probabilities (PEP) of the variables averaged over. The posterior model probability (PMP) of the best model averaged over is also reported. The stepwise model is selected based on Akaike's information criterion (AIC).

	Bayesian model averaging			Stepwise AIC		
	Coef	SE	PEP	Coef	SE	P-value
Loans past due 90+ days	15.225	1.531	100	14.990	1.550	< .001
Nonaccrual loans	11.183	1.365	100	10.210	1.390	< .001
Foreclosed real estate	14.361	1.795	100	13.950	1.801	< .001
Equity	-2.858	1.191	93.8	-2.684	0.952	0.005
Net income	-0.554	1.642	12.3	-3.534	1.708	0.039
Securities	-4.621	0.388	100	-4.956	0.380	< .001
Loan loss reserves	0.124	0.873	3.2	-	-	-
Jumbo CDs	4.751	0.260	100	4.852	0.256	< .001
Cash	-0.067	0.279	7.3	-1.203	0.552	0.029
Demand deposits	0.011	0.105	1.8	0.822	0.505	0.103
Federal funds purchased	0.059	0.348	4	-	-	-
Volatile liability expense	0.018	0.120	3.1	-	-	-
Charge-offs	7.262	2.774	90.8	4.619	2.246	0.040
Brokered deposits	0.004	0.030	3.1	-	-	-
Non-interest expense	-	-	-	-	-	-
Insider loans	4.115	0.537	100	4.170	0.534	< .001
Dividends	0.401	1.933	5.4	7.576	4.294	0.078
Age	0.002	0.002	54.2	0.003	0.001	0.005
Size	-0.143	0.036	100	-0.158	0.033	< .001
Provisions for loan losses	0.099	0.837	1.4	-	-	-
C & I loans	2.274	0.311	100	2.091	0.314	< .001
Consumer loans	-	-	-	-	-	-
Commercial real estate	3.080	0.537	100	2.827	0.539	< .001
Agriculture loans	1.833	0.435	100	1.646	0.414	< .001
Federal funds sold	-1.531	0.573	95.6	-1.889	0.489	< .001
Observations	13994			13994		
Models averaged over	24					
PMP of the best model	.25					

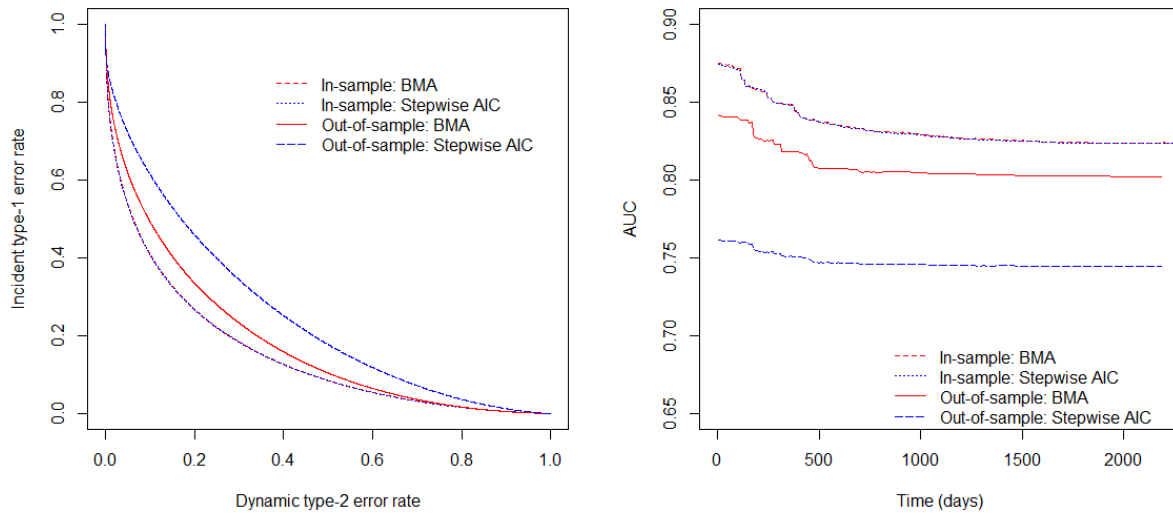


Figure 1

Prediction errors from a Cox model of the time to bank failure (1985 data)

The left panel plots the relationship between dynamic type – 2 and incident type – 1 errors at 365 days using Bayesian model averaging and stepwise selection. In-sample accuracy is measured based on the estimates of the Cox model using year-end data from 1985 to predict time to failure during the S & L crisis period and out-of-sample accuracy is measured using these earlier periods estimates, combined with year-end data from 2008, to determine out-of-sample risk scores during the Great Financial Crisis. The right panel plots the area under the ROC curve (AUC) at various times and both in and out-of-sample for the Cox model estimated using Bayesian model averaging and stepwise selection.

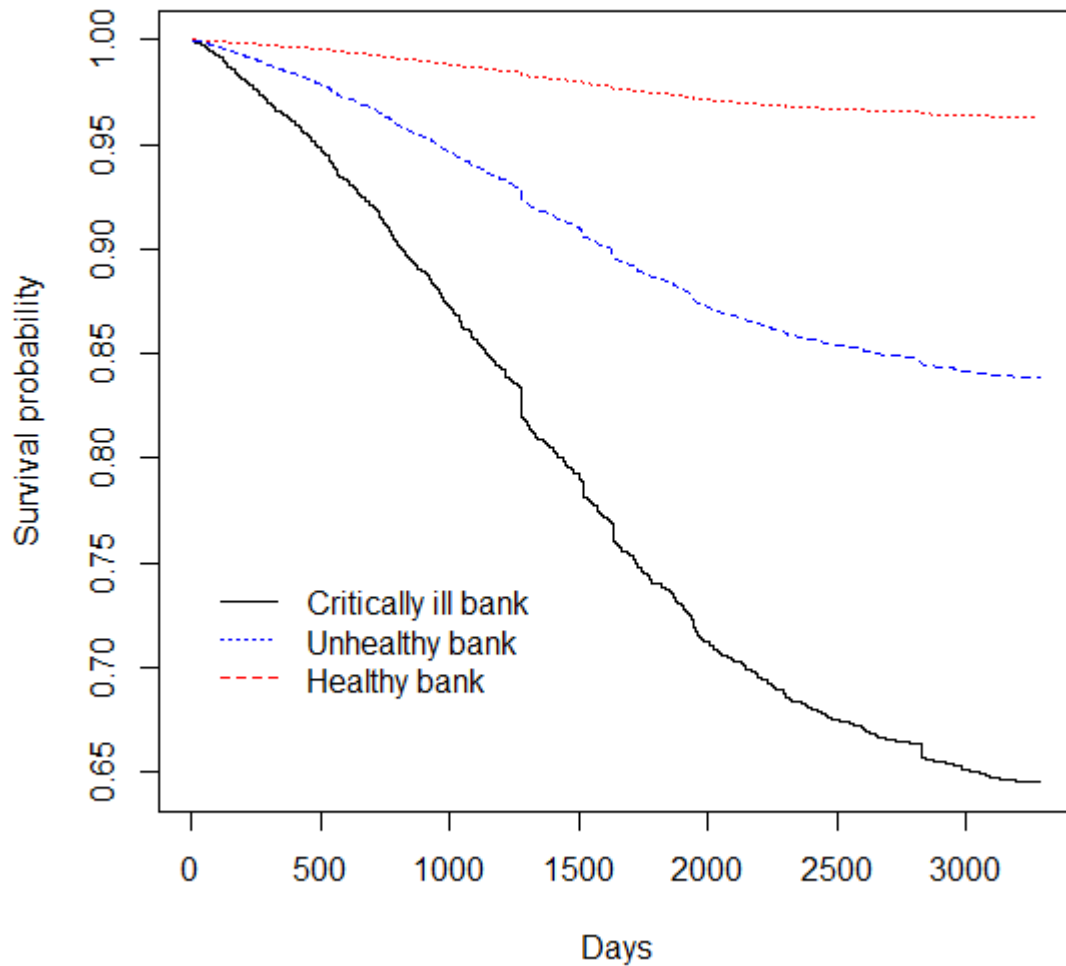


Figure 2

Estimated survival profiles of healthy, unhealthy, and critically ill banks.

Estimates are based on the survival experience of banks during the S & L crisis based on their conditions at year-end 1984. Healthy banks are defined as having risk scores equal to the mean score of banks that did not fail, whereas unhealthy banks' scores are equal to the mean risk score of banks that failed after a year, and critical banks have scores that fail within a year at risk.

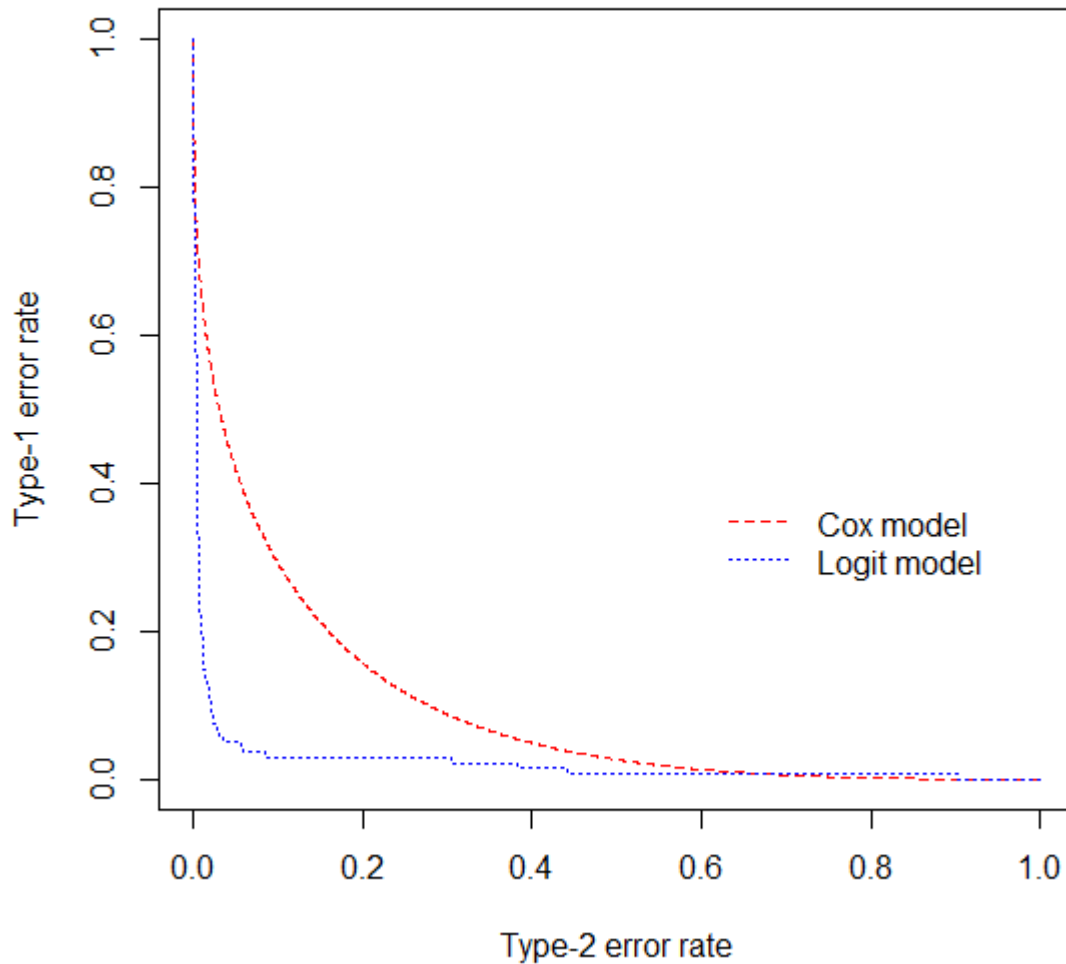


Figure 3

Prediction errors of the logit and Cox models estimated using Bayesian model averaging during the Great Financial Crisis.

The logit model estimates failures in the period 2/1/2009-2/1/2010, controlling for 2008 year-end data. The Cox model estimates the time to failure in the period year end period 2/1/2009-2/1/2015 using only year-end data from 2008. Type – 1 errors in the survival context are defined here as equal to one minus incident sensitivity, whereas type-2 errors are equal to one minus dynamic specificity (Heagerty and Zheng, 2005). Errors from the Cox model are evaluated at 365 days at risk.