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Characteristics of Banking Crises

A Comparative Study with Geographical Contagion

Ralf Fendel, Hanno Stremmel

– Electronic Appendix –

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The main paper - Fendel and Stremmel (2015) - is available in the Journal of Economics and Statistics. The electronic appendix contains further information on the indicators and also elaborates on further tests. In detail, Section A provides a detailed description on the sample. Thereby, the section exhibits the geographical distribution and elaborates on the development of country classification over time. Moreover, it provides insights into the occurrence and number of banking crisis over time. Section B contains the correlation matrix of the employed variables in the analysis. Lastly, Section C elaborates on different robustness checks such as the stability of parameter as well as additional structural variables. For more information on the context please refer to the main part of the paper.

A. Further Sample Description

The geographic allocation is exhibited in Table A1. The continent allocation is illustrated in Figure A1 and Table A2. The classification of geographic areas is based on the geo-scheme by the United Nations Statistics Division (2014). The allocation appears to be sufficiently diverse given that we incorporate countries from all regions around the world. Because of the fragmented country structure, the share of Asian countries is slightly higher.

Table A1: List of Geographic Regions

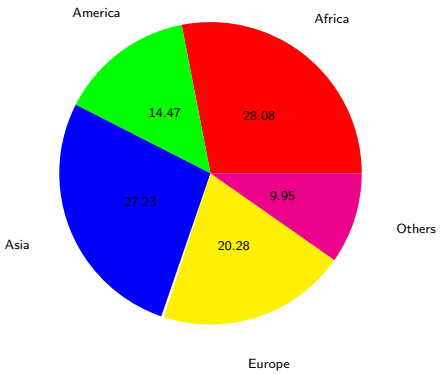
Region	Observations	Crisis	Total Quantity	Crisis Quantity
Africa (Eastern)	154	4	7.3%	5.6%
Africa (Middle)	83	0	4.0%	0.0%
Africa (Northern)	86	0	4.1%	0.0%
Africa (Southern)	75	0	3.6%	0.0%
Africa (Western)	192	2	9.1%	2.8%
America (Central)	131	6	6.2%	8.3%
America (Northern)	35	1	1.7%	1.4%
America (South)	138	9	6.6%	12.5%
Asia (Central)	25	1	1.2%	1.4%
Asia (Eastern)	91	4	4.3%	5.6%
Asia (South-Eastern)	130	6	6.2%	8.3%
Asia (Southern)	108	0	5.1%	0.0%
Asia (Western)	218	2	10.4%	2.8%
Europe (Eastern)	97	9	4.6%	12.5%
Europe (Northern)	144	12	6.9%	16.7%
Europe (Southern)	111	6	5.3%	8.3%
Europe (Western)	74	8	3.5%	11.1%
Australia and New Zealand	34	0	1.6%	0.0%
Caribbean	153	2	7.3%	2.8%
Melanesia	22	0	1.0%	0.0%
Sum	**2101**	**72**	**100.0%**	**100.0%**

Note: This table shows the geographic regions employed in the sample and the corresponding numbers of crises.

Figure A2 exhibits the evolution of country classifications over time. Overall, we are able to consider 152 countries. The number of countries increases throughout the sample until the mid-2000s. A potential explanation for this is the increasing number of developing countries but also that more data became available and thus, more

countries could be included. On the other side, the decline in the number of countries from the 2000s onward can be traced to a methodology change in the national accounts and thus constrained data availability.

Figure A1: Geographic Regions



Note: This figure shows the geographic distribution of the regions considered in this analysis.

Table A2: List of Continents

Continent	Observations	Crisis	Total Quantity	Crisis Quantity
Africa	590	6	28.1%	8.3%
America	304	16	14.5%	22.2%
Asia	572	13	27.2%	18.1%
Europe	426	35	20.3%	48.6%
Others	209	2	9.9%	2.8%
Sum	**2101**	**72**	**100.0%**	**100.0%**

Note: This table shows the continents included in the sample and the corresponding numbers of crises.

In addition, Figure A2 highlights the fact that the number of advanced countries increased over the study period. Compared with the surge in developing countries, this increase is based on developing countries' transitions to becoming advanced.

Note: This figure shows the number of countries and how they progress during the study period classified by development stage: advanced or developing.

Figure A2: Country Classifications

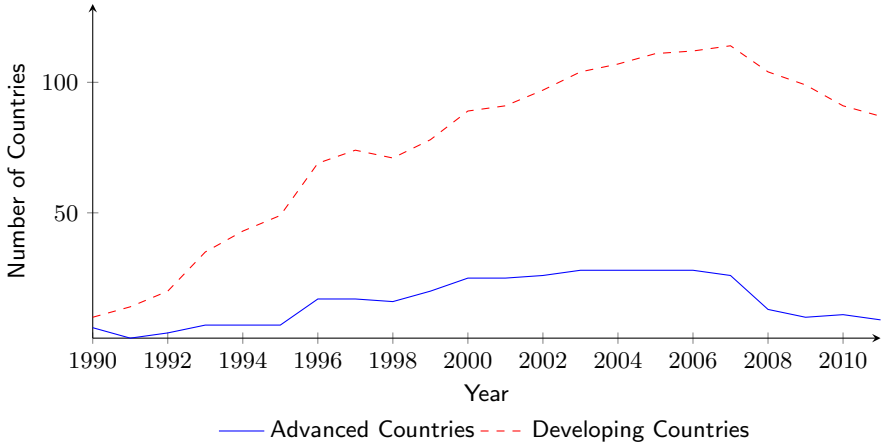
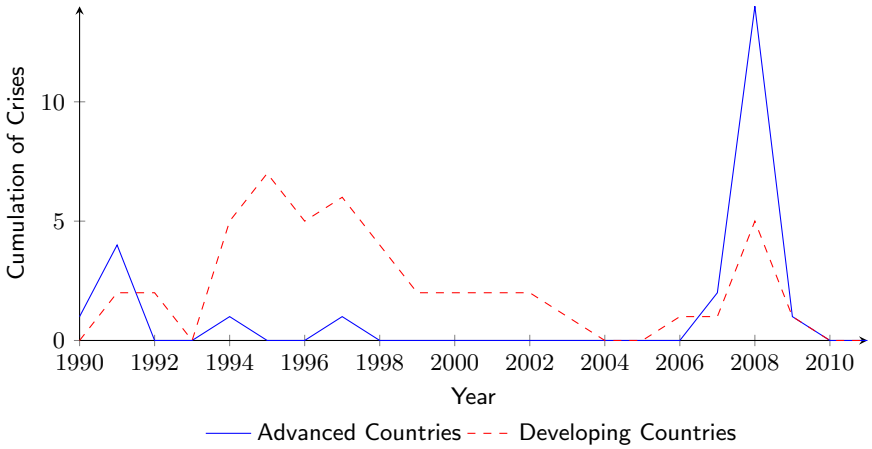


Figure A3: Number of Banking Crises over Time



Note: This figure shows the occurrence of banking crises over time across advanced and developing countries.

The country coverage and the corresponding crisis events are listed in Table 2 in the paper Fendel and Stremmel (2015). In addition, Figure A3 elaborates on the allocation of events across time. This figure illustrates that at least one crisis was triggered in each period; in only the years 2004-05 and 2010-11 was no new crisis. This figure also suggests that crisis episodes tend to cluster in time, with three clear clusters. One cluster is situated in the early 1990s, which coincides with the Nordic Banking Crisis. The second accumulation is toward the end of the 1990s, corresponding to the financial crises in emerging markets, predominately in Asia. The third cluster of crises is in the late 2000s, which corresponds to the 2007/08 global financial crisis. The first and last clusters appear to be predominantly driven by advanced countries, whereas the crises at the end of the 1990s predominantly occurred in developing countries.

B. Correlation of the Variables

Table B1: Correlation Matrix

Correlation	Bank.	Credit.	Depos.	M2.	GDP.	Infl.	Inv.	Con.	Dep.Ins.
BankEfficiency	1								
Credit/GDP	-0.12*	1							
DepositRate	0.06*	-0.25*	1						
M2/GDP	-0.14*	0.76*	-0.22*	1					
GDPCapita	-0.13*	0.67*	-0.22*	0.60*	1				
Inflation	-0.04*	-0.07*	0.53*	-0.05*	-0.04*	1			
Investment/GDP	-0.20*	0.14*	-0.03	0.12*	0.01	0.05*	1		
Contagion	0.11*	-0.01	0.25*	-0.03*	-0.00	0.09*	-0.05*	1	
DepositInsurance	0.07*	0.26*	-0.05*	0.19*	0.30*	-0.04*	-0.05*	-0.05*	1

Note: This table provides the Pearson correlation coefficients (* $p<0.1$) for the employed contemporaneous variables: BankEfficiency, Credit/GDP, DepositRate, M2/GDP, GDPCapita, Inflation, Investment/GDP, Contagion and DepositInsurance. The correlations for the other indicators are shown in Table tab:svariablescorr. For detailed information, see the description in Section 2 in Fendel and Stremmel (2015).

Table B1 presents the correlation coefficients of the contemporaneous variables. In general, individual indicators are weakly correlated with each other. Problems arising from multicollinearity in our estimation are therefore limited. Three correlation pairs have higher correlations, but none of them comes as a surprise. *Credit/GDP* is correlated to *M2/GDP* as well as to *GDPperCapita*. These relationships are not surprising because both variables follow similar concepts and are used to capture financial depth. In addition, it is also not surprising that the supply of credit is linked to the country's GDP per capita. Credit supply is an important driver of economic development. Moreover, there is a higher correlation between the deposit interest rate and inflation. However, this has a tautological foundation. A major concern in setting a deposit interest rate is expectations regarding current and future inflation. Hence, all three higher correlations tend not to be alarming because they are attributable to the underlying methodology or are tautological. Further, we also controlled for suspicious variance inflation factors and find no abnormality. Thus, our data set does not appear to contain any serious correlation issues.

C. Robustness Checks

C1 Stability of Parameter

To investigate the time stability of our specification, we divide the sample into different parts. Arbitrarily, we divide the total sample into subsamples and compare the parameter fits. In total, we investigate two different cut-offs, using the regional fixed-effects model because of the limited number of observations.[1] First, we divide the sample at its midpoint in time. Second, we test whether the 2007/08 Global Financial Crisis is different from previous crises.

Table C1: Stability of the Parameters in Different Samples

Indicator	Model (1) Full Sample	Model (2) Pre 2000	Model (3) Post 2000	Model (4) Pre 2007
BankEfficiency	0.0263***	0.0283**	0.0276**	0.0265***
	(3.30)	(2.17)	(2.12)	(2.61)
Credit/GDP	0.0145***	0.0594***	0.0140*	0.0341***
	(2.92)	(3.85)	(1.84)	(3.16)
DepositRate	0.105***	0.0901***	0.176**	0.101***
	(3.95)	(3.60)	(2.22)	(3.74)
M2/GDP	-0.00185	-0.0391**	-0.00442	-0.0252**
	(-0.59)	(-2.10)	(-1.04)	(-2.31)
GDPCapita	0.0339*	-0.0925***	0.0776**	-0.0561
	(1.81)	(-2.58)	(2.14)	(-1.50)
Inflation	-0.0224***	-0.0254*	-0.0246	-0.0330*
	(-3.72)	(-1.75)	(-0.67)	(-1.67)
Investment/GDP	0.0639**	0.0433	0.0271	0.0421
	(2.57)	(1.12)	(0.48)	(1.39)
Contagion	1.369***	1.126**	1.644***	1.533***
	(3.87)	(2.15)	(3.20)	(3.71)
DepositInsurance	0.489	0.513	2.166*	0.217
	(1.12)	(0.99)	(1.71)	(0.47)
Constant	-8.570***	-6.501***	-10.92***	-6.225***
	(-6.50)	(-3.08)	(-4.15)	(-2.91)
N. of Observ.	1513	488	631	1072
Fixed Effects	Region	Region	Region	Region
N. of Countries	124	91	83	105
N. of Crises	63	35	28	42
pseudo-R-squared	0.2343	0.2423	0.2959	0.2443
AUROC	0.8649	0.8558	0.8714	0.8727

Note: This table shows the slope coefficients of the panel regression estimates using the regional fixed-effects logit estimator for different subsamples. In each regression, the dependent variable is the crisis indicator described in Section 2 in Fendel and Stremmel (2015) z statistics are shown in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). In all of the regressions, there is a one-year lag of the explanatory variables relative to the banking crisis indicator.

Table C1 refers to the parameter stability test. The first column – Model (1) – mirrors the results for the total Model (1) from Table 7 in Fendel and Stremmel (2015). Model (2) corresponds to the period of 1990 to 2000, and Model (3) covers the period 2001-2011. Model (4) accounts for only the time period prior to the 2007/08 Global Financial Crisis, that is, 1990-2006. In all models, the parameters remain robust throughout the variations. Nonetheless, the variables' levels and significance do vary within the models. For example, *DepositInsurance* appear to have played a dominant role post-2000, whereas the macroeconomic variables such as *M2/GDP*, *Inflation*, and *Investment/GDP* appear to have good explanatory power for crisis episodes before the 2000s. Moreover, Model (4) demonstrates that the 2007/08 Global Financial Crisis does appear to drive the results because the Model (4) and Model (1) parameters are

[1] Despite the lower number of observations, the results of the country fixed-effects model are in line with these results.

comparable at all levels.[2] The divergence in the explanatory factors in different time periods suggests that crisis episodes do share common influences but may also have special characteristics. Despite this, the influences perform well across all different sample periods, and our specification is able to capture these different influences.

C2 Additional Structural Variables

Next, we look at the possible omission of structural influences. We add four additional structural variables to our model: *EconomicFreedom*, *FinancialOpenness*, *FinancialReforms*, and *FinancialStructure* (Table 3 in Fendel and Stremmel (2015)). We introduce the variables stepwise to our country fixed-effects model. The goal of this exercise is to investigate whether our preferred model omits any important structural explanatory power that could explain banking sector vulnerability. Omissions can potentially reduce predictive performance and/or bias the coefficient estimates. We therefore test for the presence of the four additional possible explanatory structural variables, both individually and jointly. The difficulty with the majority of these additional variables is limited data availability across countries.

Before looking at the descriptive statistics and robustness checks, we first briefly characterize the additional four structural variables. *EconomicFreedom* replicates the Index of Economic Freedom used by Miller et al. (2013). In detail, the index consists of ten economic measurements to assess the degree of economic freedom in different categories.[3] The rationale is that higher economic freedom is beneficial for economies. For example, de Haan and Sturm (2000) show that greater economic freedom fosters economic growth and stabilizes economies. In consequence, a higher degree of economic freedom is associated with a lower likelihood of a banking crisis (Baier et al., 2012).

Our second indicator, *FinancialOpenness*, measures the financial openness of each individual country and is based on the Chinn-Ito Index by Chinn and Ito (2008, 2014). This index measures the degree of openness in capital account transactions; the higher the index, the more financially open the country. Recent evidence on financial open-

[2] Nonetheless, the recent 2007/08 Global Financial Crisis also has specificities. *DepositInsurance* is not significant in Model (4). By incorporating the 2007/08 Global Financial Crisis, the coefficients become significant in Model (1). This implies that predominantly well-developed countries with distinct financial systems were affected by the crisis, which is in fact exactly what happened.

[3] The index condenses subindices of economic. monetary and financial freedom and is normalized between 0 and 1. A higher value indicates that a country has a higher degree of economic freedom. For more information on the construction and the single subindices, see Miller et al. (2013).

ness and liberalization related to banking crises is mixed for this indicator (Bekaert et al., 2011).[4]

Another indicator intends to capture the effects and impacts of financial reforms in each country on banking sector vulnerability. *FinancialReforms* utilizes the financial reform database of Abiad et al. (2010). The idea is to investigate the effect of a better-developed financial sector on its vulnerability.[5] We expect a well-developed financial sector to be less prone to banking crises.

Lastly, we account for the financial structure of each country. The indicator *FinancialStructure* was employed by Demirgüç-Kunt and Levine (2001), it attempts to indicate whether the financial system is more bank-based or market-based, and it is calculated as the total value of stocks traded divided by bank credit to the private sector. A higher value corresponds to a more bank-based financial system. Cihák et al. (2012) and Demirgüç-Kunt et al. (2012) provide detailed reviews of the background and also the relationship to economic growth. In line with the literature, we expect a bank-based financial system to be more vulnerable than market-based systems.

Table C2: Descriptive Statistics of Additional Structural Variables

Variable Name	**Full Sample**			**Tranquil Periods**			**Crisis Periods**		
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Contagion	2101	0.44	0.50	2029	0.43	0.50	72	0.65	0.48
DepositInsurance	2101	0.18	0.38	2029	0.16	0.36	72	0.82	0.39
EconomicFreedom	1550	6.71	1.03	1481	6.72	1.03	69	6.67	1.01
FinancialOpenness	865	0.72	0.20	822	0.73	0.20	43	0.64	0.16
FinancialReforms	1340	0.42	0.72	1282	0.43	0.73	58	0.39	0.63
FinancialStructure	1949	0.40	1.59	1884	0.38	1.59	65	0.82	1.58

Note: This table shows the descriptive statistics (e.g. means and standard deviations) of the additional structural indicators employed in the analysis across three different subsets (full sample and crisis and non-crisis periods): *Contagion*, *DepositInsurance*, *EconomicFreedom*, *FinancialOpenness*, *FinancialReforms* and *FinancialStructure*.

Table C3: Correlation Matrix of Additional Structural Variables

Correlation	Con.	Dep.Ins.	Eco.Fre.	Fin.Ope.	Fin.Ref.	Fin.Str.
Contagion	1					
DepositInsurance	-0.00	1				
EconomicFreedom	0.31*	-0.12*	1			
FinancialOpenness	0.35*	-0.15*	0.74*	1		
FinancialReforms	0.07*	-0.08*	0.24*	0.19*	1	
FinancialStructure	0.34*	-0.01	0.76*	0.74*	0.11*	1

Note: This table provides the Pearson correlation coefficients (* $p<0.1$.) for the levels of the employed contemporaneous variables: *Contagion*, *DepositInsurance*, *EconomicFreedom*, *financialopenness*, *FinancialReforms* and *FinancialStructure*. The correlations for the other indicators are shown in Table B1. For detailed information, see the description in Section 3 in Fendel and Stremmel (2015).

[4] For more information on this relationship, see Bekaert et al. (2011), Ranciere et al. (2006) and Rousseau and Wachtel (2011).

[5] Previously, we only indirectly approximated financial sector development stage with an imperfect indicator such as M2/GDP or GDPCapita. Now, we directly measure Financial-Reforms.

Table C2 illustrates the descriptive statistics and Table C3 the correlation matrix of the structural variables considered in this investigation, respectively. *Contagion* and *DepositInsurance* are two known structural indicators that we also introduce here. The four structural indicators appear to be well determined. Table C2 reveals that the data availability for the additional structural variables is of great concern and that availability is lower than that for the two previously used structural variables. The four new variables are not particularly correlated to the previously used indicators (Table C3). In contrast, the correlation matrix suggests an interrelation between the new structural indicators. However, this is not a major issue because the indicators are not supposed to be employed jointly.

Table C4: Robustness using Future Structural Parameters

Indicator	Model (1) Full Sample	Model (2) Eco. Fre.	Model (3) Fin. Ope.	Model (4) Fin. Ref.	Model (5) Fin. Str.	Model (6) All Str. Var.
BankEfficiency	0.0185*	0.0213*	0.0209	0.0195*	0.0197*	0.0602
	(1.95)	(1.81)	(1.02)	(1.86)	(1.71)	(0.88)
Credit/GDP	0.106**	0.113**	0.152***	0.129**	0.148**	0.216***
	(2.28)	(2.31)	(3.64)	(2.20)	(2.26)	(3.23)
DepositRate	0.204***	0.189***	0.148**	0.161***	0.191**	0.248**
	(2.83)	(3.28)	(2.52)	(2.86)	(2.35)	(2.08)
M2/GDP	-0.0570*	-0.0449	-0.0534	-0.0812**	-0.0978**	-0.124*
	(-1.81)	(-1.44)	(-1.63)	(-2.02)	(-2.08)	(-1.92)
GDPCapita	0.209***	0.200***	-0.413	0.277***	0.291**	-0.244
	(3.07)	(2.72)	(-1.34)	(2.73)	(2.30)	(-0.63)
Inflation	-0.0891**	-0.118***	-0.101**	-0.0825**	-0.129**	-0.245**
	(-2.54)	(-3.16)	(-2.18)	(-2.43)	(-2.12)	(-2.10)
Investment/GDP	0.162**	0.207***	0.103	0.212***	0.310***	0.186
	(2.51)	(3.18)	(1.29)	(3.77)	(4.04)	(0.81)
Contagion	2.041***	1.893***	1.919***	1.883***	2.905***	5.094***
	(2.83)	(2.69)	(3.28)	(2.65)	(2.74)	(2.66)
DepositInsurance	-1.899	-1.609	-1.230	-1.204	-2.405	-2.123
	(-1.29)	(-1.19)	(-0.74)	(-0.90)	(-0.75)	(-0.87)
EconomicFreedom		-1.521***				-2.784
		(-2.87)				(-1.50)
FinancialOpenness			-0.528*			0.144
			(-1.65)			(0.16)
FinancialReforms				0.489		0.921
				(0.43)		(1.15)
FinancialStructure						0.404
						(0.66)
Constant	-9.392***	-0.117	-7.073	-8.594***	-13.03**	3.758
	(-3.63)	(-0.03)	(-1.54)	(-4.19)	(-2.21)	(0.29)
N. of Observ.	618	607	276	606	510	176
Fixed Effects	Country	Country	Country	Country	Country	Country
N. of Countries	48	47	28	47	42	19
N. of Crises	63	62	36	59	48	23
pseudo-R-squared	0.4198	0.4387	0.3771	0.4247	0.5060	0.5498
AUROC	0.9119	0.9158	0.8939	0.9147	0.9357	0.9403

Note: This table shows the slope coefficients of the panel regression estimates using the country fixed-effects logit estimator. In each regression, the dependent variable is the crisis indicator described in Section 2 in Fendel and Stremmel (2015). *z* statistics are shown in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$). In all of the regressions, there is a one-year lag of the explanatory variables relative to the banking crisis indicator. For detailed information, see the description in Section 3 in Fendel and Stremmel (2015).

Table C4 displays the six different models using structural indicators. To compare the results, we use the country fixed-effects model.[6] To facilitate the comparison, Model (1) in Table C4 replicates Model (3) from Table 6 in Fendel and Stremmel (2015). Model (2) to Model (5) add, respectively, the indicators *EconomicFreedom*, *FinancialOpenness*, *FinancialReforms*, and *FinancialStructure* to Model (1). Model (6) incorporates all structural variables. The decisive point among the models is the number of observations. The banking sector, macroeconomic and structural indicators

[6] The results are robust to the regional fixed-effects and are available upon request.

in Model (2) through Model (6) remain robust and at comparable levels to those in Model (1), although the variables' significance levels may change. Nonetheless, we can say that the effects and impacts are fairly comparable. The significance levels of the additional variables are diverging, although all have the expected direction of influence on banking sector fragility.

The indicators *EconomicFreedom* and *FinancialOpenness* are found to be significant. In detail, Model (2) suggests that a higher degree of economic freedom significantly lowers the likelihood of a banking sector crisis. Additionally, Model (3) reflects that a more financially open country is less vulnerable to a crisis. However, the additional variable only increases the ROC value, and the adjusted-R^2 values can be increased only marginally – Model (2). For Model (3) both good of fit measures actually deteriorate in comparison to Model (1). This development is accompanied by smaller sample sizes, and therefore, there are fewer observations and crises than with Model (1). The indicators *FinancialReforms* and *FinancialStructure* are not significant in our regressions. Models (4) and (5) also have considerably fewer observations than does Model (1), and the goodness of fit of Model (4) deteriorates. Model (5) features very high goodness of fit. However, adapting Model (1) to the smaller sample size of Model (4) improves the goodness of fit even more. Therefore, the excellent goodness-of-fit properties of Model (4) appear to be mainly driven by the small sample size. Although all combined structural indicators in Model (6) remain at comparable levels, they are not significant. This could indicate either overlaps in the structural indicators' explanatory power or that the results are rooted in the smaller sample size. In addition to their lack of significance, the model properties are also not favorable.

To summarize the robustness checks, the various robustness tests suggest that our initial specification (Model (1) in Table C4) is robust and that the results are stable. Based on the various assessment options and tests, we are confident that our model is capable of reliably predicting banking sector crises.

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