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Explaining bank distress in Eastern European transition economies

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ABSTRACT

This paper considers the joint role of macroeconomic, structural and bank-specific factors in explaining the occurrence of banking problems in the nineteen Eastern European transition countries over the last decade. With data at the individual bank level we show, using a discrete time survival model, that all three factors interact in their impact and have a rich dynamic profile, which underlines the highly volatile cycles challenging the stability of banks in this region. A fragile funding basis accompanied by high exposure to market risk in an environment of reforms and macroeconomic disturbances is the typical precursor of bank distress.

1. Introduction

Most of the transition countries have experienced severe banking problems over the 1990s. These economies have been undergoing major economic restructuring and changes in their financial systems. The purpose of our research is to uncover the underlying patterns of bank distress in a broad range of countries in the process of economic transition. For this reason we use micro-level data (drawn from BankScope)[1] covering 118 distress episodes and nearly 600 banks in 19 countries – Albania, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Serbia, Slovenia, Slovakia and Ukraine – over the period 1995–2004. These are complemented with a set of structural and macro-level variables from public sources. We aim at uncovering the common features of bank distress in this region and whether these features are primarily a function of difficulties unique to transition or rather similar to the patterns of bank distress observed elsewhere.

Most of the existing cross-country research on the factors that help explain the occurrence of banking problems deals with Asian or South American experience; see Rojas-Suarez (2001) for a helpful survey, Bongini et al. (2000) for a pooled study of five East Asian countries and Arena (2005) for a comparison of the two regions. Moreover, some extensive cross-country studies, Hardy and Pazarbasioglu (1998), for example, deliberately refrain from including transition countries because they feel that these former socialist economies, suffered a special range of problems that make them non-comparable with most of the other countries.

There is an extensive literature that tries to assess which variables that are observable in most countries might act as early warning indicators of systemic banking problems.[2] There is similarly an extensive range of articles that look at the prior characteristics of individual banks in a single country or market that predict which banks are more likely to get into difficulties or fail.[3] Our data enable us to look at the interaction of these two. The heterogeneity of results across countries shown in existing studies reflects a combination of the fact that they have used different definitions of failure or crisis and a varying set of indicator variables while being faced by diverse macroeconomic and structural circumstances. We

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[1] The BankScope database, run by Bureau van Dijk (http://www.bvdep.com/en/index.html) contains information on over 25,000 banks round the world.

[2] See, for example, Caprio and Klingebiel (1996), Demirgüc-Kunt and Detragiache (1999), Hardy and Pazarbasioglu (1998).

[3] The literature is particularly rich with respect to the United States, where the data are most readily available. See, for example, Calomiris and Mason (2000), Cole and Gunther (1995), Dabos and Escudero (2004), De Young et al. (1999), Estrella et al. (2000), Lane et al. (1986), Thompson (1991), Whalen (1991) and Wheelock and Wilson (2000).

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presume that the country idiosyncrasies are more pronounced in a transition environment as the banking sectors and broader economies are converging at different speeds.

It is normally argued that the European transition economies faced twin problems. They have started with state banks dominated by directed lending. Such banks have had to switch to a risk based approach and acquire the expertise necessary to run the business successfully in a competitive environment. At the same time the opening up of the economy to market forces attracted a large number of new entrants, mainly small private banks. The authorities were unprepared for this environment, both in being able to prepare banks for the rigours of the new regime or in detecting problems and assisting in their solution. In many cases the banking system had to face a two-stage problem. In the first instance the banks were overwhelmed by the scale of the macroeconomic pressures on the whole range of their customers. In the second, their lack of experience in liquidity and risk management led to further problems, exacerbated by any external shocks.

In this paper we explore how the experience of banks across the European transition economies conforms to this pattern. However, we anticipate that bank behaviour in transition economies becomes gradually more reminiscent of the experience in other market economies. The most advanced transition countries already have banking and regulatory structures similar to those of their Western European counterparts, assisted by considerable foreign ownership.

The paper is organized as follows. Section 2 gives the framework for addressing the research problem, defines distress and introduces the early warning variables. Section 3 deals with empirical analysis, providing a description of the data and discrete time survival analysis methodology we use. Section 4 discusses the estimation results, while Section 5 explores the in and out of sample predictive power. Section 6 concludes.

2. The framework for addressing the problem

The comparative studies of emerging markets have severe concerns over the data. As a result such cross-country studies tend to focus mainly on readily available and prima facie compatible macroeconomic data. In these papers, GDP growth, inflation, exchange rate movements and the terms of trade serve as the warning signals of banking problems, as they all indicate sources of pressure on bank income flows and balance sheets. These broad-based macro-indicators can sometimes be complemented by a set of aggregate banking sector variables such as credit to the private sector, deposits and banking sector foreign reserves. Detailed differences aside, the general conclusions of macro-data driven studies are consistent and intuitive. In brief the results reaffirm that a deteriorating macroeconomic situation and underlying instabilities precipitate bank distress and failure. These results have much in common with the findings for OECD countries, as is illustrated in Mayes et al. (2001, Chap. 2) for the Nordic countries.

Demirgüc-Kunt and Detragiache (1998) focus on a further potential trigger of financial distress that is relevant for our study, namely, financial liberalization, as it is an example of a financial regime change. Their results indicate that financial liberalization exerts a negative effect on the stability of the financial sector that is additional to those from adverse macroeconomic developments and related vulnerabilities to balance-of-payments crises. A strong institutional environment can however alleviate the adverse impact of liberalization on the financial system. Unfortunately their study does not include transition economies.

Notwithstanding the valuable insights from previous studies there is little evidence on how authorities such as central banks and supervisory agencies could make use of financial fragility indicators in order to safeguard the stability of the banking system. Similar problems exist in finding clear evidence on why some banks survive the adverse macroeconomic conditions and external shock whereas the others fail. There are several studies, mainly based on US and a few Latin-American countries' banking data (e.g. Gonzalez-Hermosillo, 1999, 1997; Rojas-Suarez, 1998) that try to explore specific banking sector indicators which can serve as valuable early warning signs of banking distress. The particular value of these studies lies in using as indicators a set of factors, which can be addressed directly by appropriate banking regulation and supervision authorities under the CAMELS[4] framework, which is applied in the US and has been adapted elsewhere. Hence the chances of distress can be reduced by preventive actions.

We assume that the degree of fragility of individual banks is closely linked to the overall propensity to banking crisis (and to contagion), in which the bank-specific factors play an important role in systemic stability.

2.1. Specification of the model

In our model bank distress, d, depends upon three groups of variables: macroeconomic conditions, m, banking sector structure, s, and factors related to the financial condition and characteristics of individual banks, b

$$d = f(m, s, b). \tag{1}$$

A bank is defined as being in distress when at least one of the following criteria is met according to the information from BankScope database: (1) Bankruptcy, (2) Dissolved, (3) In liquidation or (4) negative net worth. The banks not falling into any of the categories above are labelled 'sound' if they have been active and reporting for at least three years.

2.2. Early warning indicators

The choice of early warning indicators of impending problems is heavily constrained by the data available. The wider the sample of countries, the narrower will be the choice. In Table 1, we set out the indicators that have been used in a number of recent studies along with the signs of estimated parameters recorded. These indicators of the probability of bank failure can be divided into: those that are bank specific, those that reflect banking sector structure, and macroeconomic or external factors that affect all banks. Overall there is no universal set of indicators used across previous studies, although there is more commonality over broad-based macro-variables, such as GDP, exchange rate and inflation indexes, which have better cross-country comparability and availability. By contrast the set of bank-specific variables varies a great deal across the studies. Even ostensibly similar bank-specific variables may not be comparable across countries, as the accounting regulations and supervisory rules can be very different.

The basis for comparison for the bank-specific variables used in Table 1 is fairly limited and relies on US and Latin-American countries' data.[5] However there are also studies of bank level data such as Dabos and Escudero (2004) for Argentina, Henebry (1997) for US banks and others, which serve as good comparisons here.[6]

Five of the CAMELS categories are distinguished with their expected signs given in parenthesis: Capital i.e. solvency (−), Assets

[4] Capital adequacy, Asset quality, Management soundness, Earnings and profitability, Liquidity, Sensitivity to market risk (CAMELS).

[5] This summary table is far from a complete survey and should be rather considered as an illustration, not a conclusive statement of the similarities and differences across present literature.

[6] Calomiris and Mason (2000) also provide a helpful example, as their study of banks in the US depression contradicts widely held views on the importance of some bank-specific variables.

Table 1
Summary of earlier studies: early warning variables of bank failure probability

Bank-specific variables			Capital-asset ratio	Asset risk (variable)	Earnings (variable)	Liquidity ratio	Sensitivity (Sensitive funding)
Arena, 2005: Argentina, Mexico, Chile, Colombia, Peru: 94–96. Venezuela: 93–95			–	+ (loans-assets)	n.s (ROA)	–	n.a.
De Young et al. (1999). US: 1985:Q1-1998:Q4			n.s.	+/+ (NPL/loans-assets)	n.a.	–	+ (large deposits)
Whalen (1991). US Jan. 1987–Oct. 1990			–	+ (loans-assets)	– (ROA)	n.a.	+ (large deposits)
Gonzalez-Hermosillo et al. (1997) Mexico: 1991:Q4-1995:Q4			–	+ (NPL ratio)	– (profit margin)	–	+ (inter-bank funds)
Gonzalez-Hermosillo (1999)	US	SW (1986–1993)	–	+/+ (NPL/loans-assets)	–/+ (ROA)	–	+/– (bank deposits)
		NE (1992–1993)	–	+/+ (NPL/loans-assets)	– (ROA)	–	– (bank deposits)
		California (1992–1993)	–	+/+ (NPL/loans-assets)	– (ROA)	–	– (bank deposits)
	Mexico (1994–1995)		–	+/+ (NPL/loans-assets)	– (profit margin)	–	+ (bank deposits)
	Colombia (1982–1987)		–	n.s./n.s. (NPL/loans-assets)	+ (ROA)	–	+ (bank deposits)
Macroeconomic and banking sector variables			Economic activity (GDP or income growth)	Financial deepening (Loans to GDP)	Average annual CPI growth	Currency devaluation	Real interest rate
Gonzalez-Hermosillo et al. (1997) Mexico: 4q1991–4q1995			– exp	+	+ exp	n.s.	+
Demirgüc-Kunt and Detragiache (1998, 1999): Panel of 65 countries 1980–1995			–	+	+	n.s.	+
Hardy and Pazarbasioglu (1998), 38 country panel, 1980–1997			–	– Lag(2) +	+ Lag(2) –	– Lag(2) +	+ Lag(2) +
Hutchison and Mc-Dill (1999), 67 country panel, 1975–1997			–	–	+	+	+
Gonzalez-Hermosillo (1999)	US	SW (1986–1993)	–	–	n.a	n.a	+
		NE (1992–1993)	–	n.s.	n.a	n.a	–
		California (1992–1993)	–	+	n.a	n.a	–
	Mexico (1994–1995)		n.a.	+	n.a	+	+
	Colombia (1982–1987)		n.a	+	n.a	n.a	n.a

Dependent variable

(1) Arena: **Bank failure** – the incidence of intervention or closure, bank has been absorbed or acquired by another institution.
(2) De Young, Hasan and Hunter define **Bank failure** as one of the following: (a) a bank was declared insolvent by the regulator; (b) a bank received regulatory assistance; (c) a bank was acquired after its net worth had declined to less than 1% of its assets.
(3) Whalen (1991): FDIC designated failure date, date that FDIC funds are disbursed.
(4) Gonzalez-Hermosillo et al. (1997): **Bank Failure** – Occurrence of bank intervention in form of financial assistance, recapitalization, etc.
(5) Gonzalez-Hermosillo (1999): **Bank Failure** – the incidence of intervention; **Distress** – Coverage ratio, i.e ratio of capital equity and loan reserves minus nonperforming loans to total assets.
(6) Demirgüc-Kunt and Detragiache (1998, 1999), Hutchison and Mc-Dill (1999): Definition of (systemic) **financial crisis** based on Caprio and Klingebiel (1996, 2003) and Lindgren et al. (1996). For an episode to be classified as crisis at least one of following conditions must apply: (a) NPL to total banking sector assets above 10%; (b) Ratio of NPL to total assets greater than 2% of GDP; (c) The cost of rescue operation at least 2% of GDP; (d) Large scale nationalization; (e) Extensive bank runs; (f) Emergency measures applied such as deposit freezes, prolonged bank holidays, deposit guarantees.

n.a. – not available; n.s. not significant, Exp – expected sign. NPL – nonperforming loans, ROA – return on assets.

i.e. credit risk (+), Earnings (+/−), Liquidity (−), Sensitivity (−/+). All of which are conventional measures of bank soundness. Information on the remaining M, 'Management', category is not readily available.

The papers dealing with US and Latin-American banks do not always report consistent results for the same indicators. Most of the studies confirm that a higher liquid assets ratio tends to reduce the probability of bank distress but the bank deposits ratio is far more controversial, having even opposite and statistically significant coefficients in the different bank samples. Extensive lending in the form of a higher loan-to-assets ratio and a higher share of nonperforming loans (NPL) is usually a trigger of a crisis with the sole exception of Colombia where there is no significant evidence. Strong return on assets (ROA) is mostly good protection against the risk of failure, although the evidence from Colombia shows the reverse. One of the most consistent indicators appears to be the capital-asset ratio,[7] although De Young et al. (1999) showed that it was not significant in explaining probability of survival for de novo or newly established banks in the US. Taken together, these studies do not give a clear signal of what to expect for our sample of transition economies.

The results for macroeconomic indicators are in better conformity,[8] moreover the studies under consideration incorporate large cross-country samples all over the world.[9] The prevailing evidence shows that GDP growth improves the banks' outlook for survival, whereas increasing inflation is mostly a factor accompanying bank distress. However, here also some studies come up with conflicting evidence. According to most studies, financial deepening seems to increase vulnerability, however there are exceptions. It is not immediately apparent what result we should expect. Financial deepening is a sign of economic maturity so a negative sign would be plausible.

The same ambiguity applies to currency depreciation as a possible precipitator of bank problems. Here, the ambivalent results might stem from cross-country differences in monetary policy

[7] This is clear from the US studies; Estrella et al. (2000) show it is robust to a number of definitions of capital and Thompson (1991) shows it is a good predictor of banks causing the supervisors concern.

[8] Qualiariello (2005) finds that only the growth of real GDP, investment, credit and asset prices play an important role in predicting bank loan quality in Italy.

[9] The multi-country models are typically trying to detect systemic banking crises. However, the evidence of the relationship between macro-variables and bank distress is so strong that it seems sensible to use these broader studies as an indicator of the likely determinants.

(inflation targeting versus exchange rate targeting), country comparative competitive advantages, the level of financial deepening or general stability and maturity of the economic environment. In any case the impact would depend on how well the banks and their customers were hedged, itself a feature of financial deepening. Beck et al. (2006) offer some evidence on structural factors.

Also important to note here is that the variables behave in a different manner depending on how far ahead you look (Lane et al., 1986). Timing is a critical issue, as signalling variables will be subject to endogenous feedback as problems evolve. A variable that provides a warning some time in advance of distress may be changed rapidly by the bank's response to the pressure and hence even give the opposite signal later. In these circumstances, as Arena (2005) suggests, financial ratios provide information about symptoms rather than causes of financial difficulty.

3. The empirical study

3.1. The data

Much of the novelty of the present paper is attributable to the underlying data. The study uses micro and macroeconomic variables drawn from BankScope, *International Financial Statistics*, Eurostat, EBRD Transition reports and from national central bank sources for 19 CEE countries. The set of countries includes the 10 new EU member states;[10] Republics of Former Yugoslavia – Croatia, Macedonia, Bosnia-Herzegovina and Serbia; and the 'European' republics of the Former Soviet Union: Belarus, Moldova and Ukraine as well as Russia and Albania, over the years 1995–2004. A major advantage of our database is that it includes banks in a group of similar countries recorded for several years. We can therefore pool the data and consider the role that different country circumstances play in bank distress.

We rank the countries according to the progress in liberalization and institutional reforms in the banking sector measured by the average EBRD banking sector reform index[11] over 1995–2004 (Fig. 1). In general the new EU members demonstrate better progress in banking reforms than the other participants in the study. The exception is Croatia, which belongs to the frontline of transition countries in respect of banking sector reforms. We have therefore divided the sample countries into two groups, which we label 'advanced transition countries', including 10 new EU member countries *and* Croatia, while the rest of the countries form a 'less advanced transition country' group. Hence the dividing line lies between Romania and Macedonia in Fig. 1.

Due to a large number of missing entries the initial sample of about 1300 banks was reduced to about 600 banks in the econometric analysis.[12] Table A1 shows the number of distress incidences in the full dataset broken down by year and country. Distress is concentrated, with a quarter of the episodes occurring in 1997. The overall distress frequency was 5.6%, which is less than in the reduced sample for econometric analysis – 7.2%. The gaps in the data and the selection bias from the difficulty in getting information from failed organizations may mean that distress is under-recorded in the less advanced transition countries.[13] Estimating the relationships separately for the more advanced and less advanced transition countries may reduce the impact.

3.2. Methodology

We estimate Eq. (1) using survival analysis, as this method is becoming the preferred approach for investigating business failure (Lane et al., 1986; De Young et al., 1999). An advantage of survival models over the conventional logit models is that they recognize that the probability of the bank becoming distressed may vary over time.

The underlying concepts of the survival analysis are the survivor function and the hazard function (hazard rate) (Kiefer, 1988). Our data set provides observations only discretely, covering a year at a time. Hence, we track each bank, i, from year $k = 1$, when it enters the data set through to the end of year j, at which point the bank's spell in the data is either complete because the bank becomes distressed or censored because the end of the observation period has been reached.[14] The survivor function reflects firm's probability of surviving beyond year j

$$S_i(j) = \Pr(T_i > j). \tag{2}$$

In discrete time analysis with yearly data, the hazard function or conditional failure rate is the probability that a failure event occurs within a given year j conditional on surviving until this particular year.

$$h_{ij} = \Pr(T_i = j | T_i \geqslant j). \tag{3}$$

Each time unit (year) is viewed as an independent Bernoulli trial, being defined as 1 if the bank becomes distressed and 0 otherwise. The indicator can therefore only be one in the final trial, so the conditional log-likelihood remains binomial and can be estimated with standard techniques for binary data (Guo, 1993). Discrete time survival models are also convenient because the hazard rate can be interpreted in terms of probability of distress.

The survival time is counted as the number of years a bank has been in business. We do not control for the unobserved heterogeneity, which can probably be neglected because banking is a relatively standardized industry, being subject to numerous regulations which share major commonalities on an international and regional level, such as Basel rules and recommendations and European banking regulations.

Time-varying covariates offer an opportunity to examine the relation between the distress probability and the changing conditions under which the distress takes place (Guo, 1993). We have opted for what is labelled a complementary log–log model (cloglog) for linking the bank's hazard rate to the time-varying covariates.[15] In practice, the variation in baseline hazard γ_j from interval to interval is specified either by dummy variables or by a linear or quadratic function. We opted for a linear $\log(\gamma_j)$ function. The cloglog hazard with time-varying covariates has the form:

$$\log(-\log[1 - h_j(\mathbf{X})]) = \gamma_j + \boldsymbol{\beta}'\mathbf{X} \tag{4}$$

where $\mathbf{X}$ contains time-varying covariates and intercept. The hazard rate is derived from (4) as follows:

$$p(t) = 1 - \exp[-\exp(\gamma_j + \boldsymbol{\beta}'\mathbf{X})]. \tag{5}$$

[10] The 10 new Member States in our study include Romania and Bulgaria, who joined on 1st January 2007, but exclude Cyprus and Malta from the 10 who joined on 1st May 2004, as they are not normally regarded as transition economies.

[11] The EBRD banking sector reform index provides a ranking of progress in liberalization and institutional reform of the banking sector, on a scale of 1 to 4+. A score of 1 represents little change from a socialist banking system apart from the separation of the central bank and commercial banks, while a score of 4+ represents a level of reform that approximates the institutional standards and norms of an industrialized market economy, as represented, for example, by the Basle Committee's Core Principles on Effective Banking Supervision and Regulation.

[12] The panel drop-out properties did not justify the weighting of remaining panel members.

[13] In advanced countries the distress occurence was 7.8% against the 3.7% distress rate for the less advanced countries over the years 1995–2004.

[14] We have no information about whether the bank survived or failed thereafter.

[15] There several well-known formulations that could be used, but since our hazard is relatively small and exit not inevitable (as it is for human beings) this particular linearization is attractive. Future research could experiment with a wider variety of forms.

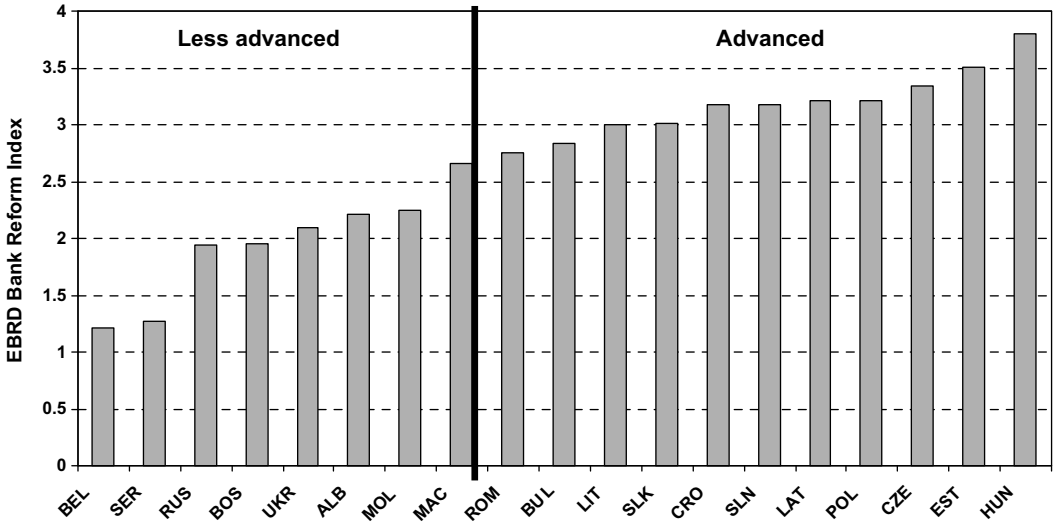

Fig. 1. EBRD banking sector reform index, average 1995–2004 (Source: EBRD Transition Report 1998–2005) (less advanced) (advanced transition).

With a cloglog model, the regression coefficients lend themselves to proportional hazard rate interpretation as in the Cox (1972) specification. Having the underlying variables in percentage form means that the coefficient captures a proportional percentage change in the hazard given a one percentage point change in the covariate. Robust standard errors are calculated in order to control for within group correlations in regard to variables, which do not vary for individual banks.

4. Results and discussion

Since our concern is with early warning, we show results from the cloglog hazard model (Table 2) two different distances prior to the distress event. The left-hand three columns show results relating to the change in variables during the year running up to distress, whereas in the right-hand three columns we introduce all the explanatory variables as changes over the year preceding distress so as to represent the 'warning' one year ahead of problems.[16] Furthermore, we also show the results separately for our two groups of 'advanced' and less'advanced' transition countries.

Interestingly the message of the early warning model is clearer than that from the contemporaneous model. This is likely to be because of endogenous effects blurring the relationship during the distress period, as those affected are simultaneously taking action to try to avert and correct the problems. The baseline hazard coefficients are positive and significant, except for less advanced countries in the early warning model, suggesting that probability of failure is increasing with time. De Young et al. (1999) found that in the US de novo banks are less likely to fail in their first five years in business compared to established banks. This is because new banks start with sound capital base and have no bad loans stock to carry over. After seven years in operation the accumulated risks lead to failure rates higher compared to banks with a longer history. Most of the banks in our sample only started normal market-based banking activity in the early or mid 1990s and hence can be seen as newly established banks.

[16] Since the model is in differences, even the current period model of the left-hand three columns is in a sense forward-looking but to avoid any confusion we have labelled it'contemporaneous in the Table and labelled the model where all the determining variables are lagged one period as'early warning'.

4.1. Bank-specific variables

Liquidity variables provide a relatively strong signal about approaching problems. Volatile short-term liabilities become poorly covered by liquid assets in the pre-distress period. Inter-bank borrowing increases initially, whilst after the outbreak of problems it falls. Arguably the banks that are short of customer based funding (deposits) turn to the inter-bank market, which is however a rather volatile source of funding. When a bank is in distress the inter-bank market is no longer accessible. The extent of development of the financial system also seems to matter. Interest expenses behave differently in advanced and less advanced countries. While increasing interest expenses predict distress in more advanced transition countries, declining interest expenses prelude problems in less advanced transition countries.

Interestingly, the loan assets ratio is negative with respect to bank distress in the early warning model, except for more advanced transition countries. This is the opposite result to dominant evidence; however, it is only statistically significant close to distress. This leads to the conclusion that lending activity is underdeveloped in the early stages of transition, and is a marginal part of banks' activity in poorly developed markets – buying Treasury Bills is often a much more reliable source of income. The exposure to credit risk is still low in CEE countries and does not stand out as a warning sign of bank failure. Loan provisions decline in the pre-distress period, but the results are clearly non-significant. The usefulness of loan provisions as early warning indicators is undermined by two main factors. Firstly, loan provisions are an ex-post measure of failure risk and secondly their reporting varies heavily across countries due to different accounting standards and practices. Unfortunately the data for the other measures of loan quality – e.g. substandard loans - were either not available or only present for a very few banks.

Surprisingly the risk decreasing effect of the equity-to-assets ratio was statistically significant only for the more advanced transition countries. The relatively weak result is even more striking as one of the distress criteria was bank's negative net worth. Thus the level of capitalization per se is not a strong indicator of bank distress, at least in the early phases of transition, where the regulatory capital requirements are often higher than in advanced countries. Probably not the high leverage, but rather the asset composition is a critical factor in transition banking. The other common explanation is that shortness of capital is more an ex-post indicator than an early sign of potential distress. Sundararajan et al. (2002)

Table 2
Cloglog hazard model results with exponent form coefficients

Indicators	Contemporaneous (L_0–L_1)			Early warning model (L_1–L_2)		
	All	Advanced	Less advanced	All	Advanced	Less advanced
Baseline hazard	1.074***	1.111***	1.047***	1.055***	1.100***	1.042
	(7.1)	(7.5)	(3.1)	(3.54)	(5.82)	(1.33)
Liquidity and sensitivity of funding						
Volatile short-term liabilities to liquid assets i.e. inverse liquidity ratio	0.999	0.989	1.043**	1.038*	1.011	1.106
	(−0.51)	(−1.06)	(2.42)	(1.76)	(0.52)	(1.54)
Bank deposits to customer deposits	0.999**	0.999	0.996**	1.026**	1.028***	1.141*
	(−2.32)	(−0.84)	(−1.5)	(2.02)	(3.14)	(1.86)
Interest expenses to liabilities	1.120	0.889	1.182	0.828	2.541**	0.007**
	(0.77)	(−0.35)	(0.93)	(−0.35)	(2.22)	(−2.6)
Assets composition and credit risk						
Loan asset ratio	0.921*	0.971	0.806	0.984	1.010	0.789
	(−1.46)	(−0.34)	(−1.41)	(−0.19)	(0.11)	(−0.7)
Provisions to loans ratio	0.992	1.012	1.042	0.963	0.990	0.945
	(−0.38)	(0.38)	(0.42)	(−0.25)	(−0.1)	(−0.1)
Capital						
Equity-to-assets ratio	0.851*	0.767**	0.891	0.897	0.788*	0.553
	(−1.83)	(−2.19)	(−0.58)	(−0.69)	(−1.65)	(−1.35)
Sensitivity to market risk						
Equity investments to assets ratio	1.088	1.399	0.947	7.381***	2.561**	39.153*
	(0.31)	(1.24)	(−0.17)	(3.00)	(2.18)	(1.66)
Trading income ratio	1.000	1.001	0.999	0.998*	1.003	0.997
	(−0.18)	(1.01)	(−1.5)	(−1.7)	(1.00)	(−1.17)
Earnings and efficiency						
Cost-income ratio	1.001	1.021*	0.995	0.939*	0.961	0.965
	(0.26)	(1.9)	(−1.03)	(−1.97)	(−1.51)	(−0.33)
Interest and fee income to total assets	0.916	1.185	0.978	1.108	0.713	4.591*
	(−1.22)	(1.05)	(−0.18)	(0.31)	(−1.05)	(1.92)
Macroeconomic and structural indicators						
Private lending to GDP	0.844	0.855	0.460**	1.591**	2.354***	1.971
	(−1.11)	(−0.81)	(−2.2)	(2.09)	(2.92)	(0.88)
GDP real growth	1.174	0.989	1.378	0.683	1.378	0.195*
	(0.93)	(−0.04)	(1.37)	(−1.33)	(0.58)	(−1.64)
CPI growth	1.011	0.895	1.017	0.913***	0.526***	0.756*
	(0.42)***	(−1.11)***	(0.47)***	(−2.74)	(−2.7)**	(−1.68)***
EURIBOR_3mth	6.622	7.952	6.532	0.357	0.104	0.094
	(4.56)	(3.42)	(3.59)**	(−1.77)	(−2.44)*	(−2.82)
Exchange rate change (domestic currency/$)	1.008	1.031	1.042	1.013	1.240*	1.042
	(0.47)*	(0.29)	(2.15)	(0.64)	(1.62)	(0.84)
Share of foreign owned banks	1.099*	1.073	1.159	0.990	1.058	0.531
	(1.94)***	(1.00)**	(0.72)	(−0.15)	(0.55)	(−0.34)
Share of state-owned banks	1.159***	1.143**	1.374	0.961	1.141	0.709
	(2.78)	(2.02)	(1.25)**	(−0.62)	(1.12)**	(−1.13)*
EBRD Bank reform index	0.831	0.378	101.42**	0.980	9.396**	0.000*
	(−0.3)	(−1.2)	(2.09)	(−0.02)	(2.07)*	(−1.62)
Herfindahl concentration index	1.000	1.001		1.001*	1.002*	
	(0.68)	(0.82)		(1.74)	(1.74)	
Stock market index	0.999	1.007	1.016**	1.003	0.986*	0.971
	(−0.1)	(1.13)	(2.08)	(0.42)	(−1.72)	(−1.17)
Bank dummies						
Listed on stock exchange	0.316***	0.259***	0.148***	0.441**	0.325***	0.384
	(−4.47)	(−4.29)	(−2.53)***	(−2.3)	(−2.55)	(−0.38)
Savingsbank (base: Commercial bank)	4.333	2.805	27.254***	4.840	2.053	229.47
	(1.59)	(1.01)	(3.67)	(1.56)	(0.99)	(1.54)
Year and country dummies	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Model statistics						
Log-Likelihood	−278.38	−169.28	−85.04	−179.26	−105.34	−25.25
Likelihood ratio index	0.35	0.40	0.37	0.48	0.54	0.76
AIC/BIC	645/882	417/604	236/388	447/677	289/470	117/262
Observations (distress)/banks/countries	1637(118) /586/19	896(85)/27 3/11	741(33)/31 3/8	1381(94) /486/19	774(67)/23 4/11	602(27)/252/8

t-Values in parenthesis. In order not to lose observations country dummies were grouped together for Albania and Bosnia, Belarus, Ukraine and Moldova and finally for Bulgaria and Romania. 'Advanced countries' are EU-10 and Croatia, the rest of countries are labelled as 'less advanced'.
All coefficients are in exponent form, the unit is 5% except for EURIBOR where the unit of measurement is 1% change over last year.
*, **, *** indicate significance at the 10, 5 and 1% levels, respectively with robust standard errors.

opposed this, claiming that banks with higher equity need to borrow less to support a given level of assets and thus have lower interest expenses, which results in higher net interest and net income. In our results, the high share of equity investments, however, turns to be a very important explanation of approaching bank problems. A high share of volatile equity investments coupled with decreasing returns on the market seems to be one of the leading explanations of bank problems in transition economies.

One of the striking results is the negative relationship between cost-income ratio and forthcoming distress in the early warning model. A lower cost-income ratio however is less a sign of improved efficiency than a result of high lending margins and volatile trading income, which enlarges the denominator of the ratio. The income to assets ratio in the less advanced transition group supports this argument, showing that a high volatile income to asset ratio is more a predictor of distress than a profitability indicator. In the more advanced countries, however, a decrease in income is a warning sign.

4.2. Macroeconomic and structural indicators

The macroeconomic and structural indicators help to explain how the environment interacts with bank problems. The ratio of private lending to GDP increases over the period ahead of distress, but this result is not significant in less advanced transition countries. Hence, distress is correlated with financial deepening ex-ante but financial contraction at the time of the crisis – i.e. those banking sectors that run up their position fastest are more likely to be at risk, ceteris paribus, but the onset of risk is associated with the need to make a rapid contraction.

Declining GDP growth is an early warning sign only in the less advanced transition countries. Risks are built up as CPI inflation slows, which strengthens real interest rates and hence triggers credit risk. This pattern of substantial change in the indicators of potential bank distress as the economy moves from expansion to contraction at the top of the cycle gets support from the EURIBOR effect, demonstrating that declining external interest rates help to build up risks in the pre-crisis period whilst the subsequent increase in interest rates brings along severe distress. Currency depreciation seems to increase banks' vulnerability and is significant for more advanced transition countries in the pre-crisis period but for less advanced countries only at the onset of distress episodes. Foreign currency borrowing followed by an exchange rate depreciation is a well-known cause of banking distress (Mayes et al., 2001, Chap. 2).

The share of foreign owned banks provides no statistically significant early warning of distress, however the close to distress estimation shows that takeovers are most frequent for distressed banks or banks on the verge of distress. This echoes Wheelock and Wilson's (2000) finding, in an empirical study based on US bank data, that the closer to insolvency a bank is, the more likely is its acquisition. State-owned banks are more inclined to become distressed and this is significant for more advanced transition countries. Progress in bank reforms shows the opposite dynamics in the two groups of countries. The speed in bank reforms is coupled with lower ex-ante probability of distress in less advanced transition countries, whereas it shows a higher distress probability in more advanced transition countries.

Bank dummies turn out to be highly informative – listed banks are strongly and statistically significantly less caught by distress. This result is expected, whilst the stylized facts reaffirm that listed firms are generally larger and stronger, their disclosure requirements make them subject to market discipline. Surprisingly, the savings banks turn out to be prone to failure in less advanced transition countries compared to commercial banks. This feature suggests that savings banks have been mostly the relicts from the old socialist banking systems and hence more vulnerable to market pressures. The likelihood of failure rises with increasing banking market concentration, while the stock market index shows that an ex-ante decrease in the stock index is associated with a higher ex-post distress probability in more advanced transition countries.

4.3. The overall picture

All in all the results show interesting patterns, some of them contradicting the evidence in other regions. Changes in bank earnings, efficiency and relative size of credit portfolio do not appear to offer early warning of distress. However, a fragile funding basis accompanied with high exposure to market risk in an environment of reforms and macroeconomic disturbances provides the typical scenario for bank distress in Eastern European transition countries. The more advanced transition countries demonstrate a higher degree of vulnerability in respect to market forces or external factors, such as stock market movements, as well as the growth in private credit. The less developed transition countries on the other hand are more prone to fail due to institutional factors, such as the progress in banking sector reforms.

The overall results suggest the whole pattern of variables tells the 'story', rather than any specific indicators. Bank distress is a complex event, which is often precipitated not just by one or two factors, but by a series of mutually reinforcing bank-specific, macroeconomic and structural variables that show considerable dynamic variation as the event evolves. The complexity of interactions between variables cannot be fully explored by parametric models such as the one employed in present study. The value of the estimation lies rather in exploration of common, dominating features of particular variables (signals) in respect to bank distress and not in providing clear formulae or threshold values for predicting a single bank distress episode.

The role of some of our indicators of probable bank distress changes quite markedly depending on how close the crisis is, in part because they are endogenous and respond to the pressures. For example, the funding of a bank in difficulty will change as other banks will tend to be the most informed lenders and hence the first to withdraw, while retail depositors will be slow to act. This endogeneity is also present at the macroeconomic level. Rapidly expanding lending tends to be a precursor of problems but rapidly contracting lending in a crisis tends to indicate greater severity and hence more distress. How the supervisors of individual banks and those responsible for the overall stability of the financial system respond to these individual indicators will therefore change as the problems evolve.

5. Predictive ability

Although the literature warns that bank distress is hard to predict, particularly in a multi-country study and transition context (Worrell, 2004), we challenge our results by exploring the in and out-of-time predictive power of the model. We use the'early warning' version of our model in prediction – looking a year ahead – and include all 19 transition countries. For the out-of-time test the model was estimated over the years 1997–2001 and used to predict outcomes in 2002–2004. Macedonia had to be omitted from the estimation as there were no distress episodes but it was included in the test – to remarkably good effect.

Distress threshold values were selected separately for each country, giving around a 90% success rate in the in-time sample, as shown in Table 3. There were 94 distress episodes in the 16 countries estimated in the in-sample model. The in-sample predictive power of the model was 89% and the success of the predictions, as indicated by the area under receiver operating curve (AUROC),[17] was as much as 94% (see the solid line on Fig. 2 below).

[17] AUROC is widely used in the natural sciences, particularly medicine, but is somewhat less common in economics and finance. The term 'sensitivity' is used for the ratio of correctly predicted distress to all distress episodes and'specificity' to mean the ratio of correctly predicted sound banks to all predictions of sound banks. They are thus 1 – Type 1 error and 1 – Type 2 error, respectively for the sample. The'Receiver Operating Curve' (in Fig. 2) is the progressive plot of sensitivity against 1-specificity through the sample of countries. The area under the curve, AUROC, is an indication of success.

Table 3
Model predictive power (in-time)

	Overall predictive power (%)	Distress occurrence (%)	Sensitivity (%)	Probability of missing distress (%)	Type II error (1-Specificity) (%)	Probability of false signal (%)
Albania	93	–	–	–	7	7
Belarus	92	8	100	0	8	8
Bosnia	88	4	100	0	13	12
Bulgaria	88	–	–	–	12	10
Croatia	87	13	75	3	11	10
Czech Rep	90	16	91	1	11	9
Estonia	90	13	100	0	12	10
Hungary	90	5	100	0	10	10
Latvia	89	7	100	0	12	11
Lithuania	91	3	100	0	9	9
Macedonia	92	3	100	0	9	8
Moldova	92	–	–	–	8	10
Poland	84	16	57	7	11	9
Romania	89	1	100	0	11	11
Russia	89	6	94	0	11	10
Serbia	82	12	50	6	14	12
Slovakia	87	15	86	2	13	11
Slovenia	85	7	50	4	12	11
Ukraine	90	1	100	0	10	10
Total	89	7	81	1	10	9

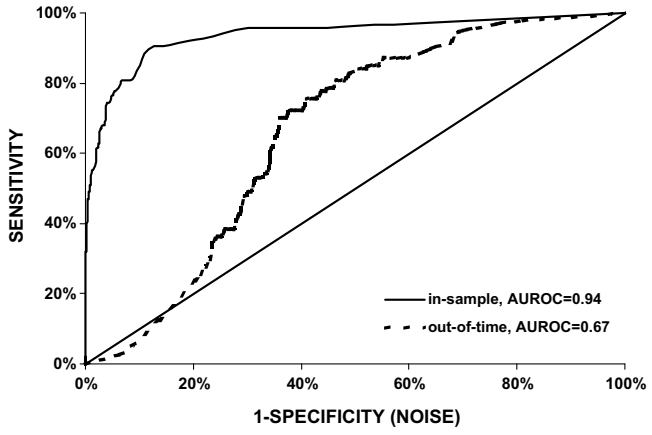

Fig. 2. Area under receiver operating curve for in-time sample and out-of-time prediction.

The last is a strong result, whereas the sensitivity of the model (the ability to recognise distress given its occurrence) was 81% while the probability of missing the distress events was 10%. At the country level the model recognized all distress episodes in 9 out of 16 countries that experienced at least one distress episode over the sample period. The accuracy of the model was weakest for Slovenia, Serbia, Croatia and Poland. In Slovenia and Serbia about half of the distress episodes were caught by the model. Interestingly these were also the countries with relatively high distress frequency. This may mean that the triggers for distress lie outside the modelled variables, such as in a different level of regulatory intervention or other specific factors.

The second step was to run an out-of-time test and see how well the model manages to recognize the distress episodes of 2002–2004, based on the estimates from the years 1997-2001, see Table 4 above. There were 16 distress episodes spread over eight countries in 2003–2004: 6 in Croatia, 4 in Russia and one in each of the remaining countries. Due to deficient data three of the distress episodes in Bosnia could not be estimated and predicted. The out-of-time prediction managed to pick up 8 out of 16 distress episodes in six countries out of eight where bank distress was present during 2002–2004.

The sensitivity of the out-of-time model (Table 4) was perfect for the Czech Republic, Hungary, Macedonia and Serbia. The result for Macedonia is the more appreciated as the out-of time model was estimated without Macedonian banks, where the first and only incidence of distress was recorded 2003. The out-of time model failed to recognize any of the distress occurrences in Slovakia and Poland, whereas for both countries the probability of false alarm turns out to be very high. The probability of false alarms was smallest for Macedonia and Hungary where the model performance was the best. Overall the 87% predictive power and 67% AUROC value are an encouraging result for an out-of-time model (see the dotted line on Fig. 2 below).

Table 4
Model predictive power (out-of-time sample)

	Overall predictive power (%)	Distress occurrence (%)	Sensitivity (%)	Probability of missing distress (%)	Type II error (1-Specificity) (%)	Probability of false signal (%)
Croatia	88	7	67	2	10	9
Czech Rep	85	2	100	0	15	15
Hungary	92	2	100	0	8	8
Macedonia	97	3	100	0	3	3
Poland	69	1	0	1	30	29
Russia	90	1	25	1	10	9
Serbia	89	2	100	0	9	9
Slovakia	65	3	0	3	33	32
Total	87	1	50	1	13	12

Table A1
The distribution of observations of distress in the dataset, 1995–2005

Year	ALB	BEL	BOS	BUL	CRO	CZE	EST	HUN	LAT	LIT	MAC	POL	ROM	RUS	SER	SLK	SLV	UKR	Total
1995														5					5
1996			1	1		1			1	1		3	1	8	1		1	1	20
1997				1	5	5	6	3	4			6	1	13	2	2	5		53
1998		2		1	2	3			1	2		3	1	2		6	1		24
1999	2	2			5	1			1			4	2	5	1	2			25
2000		2			1	1		4	1	1		3	3	4	1	2	2		25
2001			2		3	1						3	1	3			2		15
2002					3			2				1		5				1	12
2003			1		5						1			3					10
2004			2			1								3		1			7
2005															1				1
Total	2	6	6	3	24	13	6	9	8	4	1	23	9	51	6	13	11	2	197
% Fail	3.9	7.5	4.4	2	9.7	8	12.5	5.1	6.8	7	1.3	10	6.2	4.3	4.3	11.3	8.9	0.8	5.6

6. Conclusions

Using a survival model and panel data for individual banks from the BankScope database (Bureau van Dijk) complemented by macroeconomic and structural variables from publicly available sources, it is possible to find bank-specific, bank sector structure and macroeconomic variables that are able to predict vulnerabilities in the European transition countries' banking sector over the period since 1997. The results indicate that changes in bank earnings, efficiency and relative size of credit portfolio do not give an early warning of distress. However, a fragile funding basis accompanied by high exposure to market risk in an environment of reforms and macroeconomic disturbances are typical of bank distress in Eastern European transition countries. The clearest pattern observed from most of the variables is a sharp change from the expansion to contraction phases of the cycle along with adverse external dynamics. The impact of the cyclical turnaround is amplified by falling inflation, currency depreciation and a rise in foreign interest rates.

The traditional 'CAMELS' factors (we have no M, management, variables in our data) have an important role in distress detection and warning. Increasing reliance on borrowing from other banks and exposure to market risk are particularly strong negative indicators. Macroeconomic variables thus determine when problems are most likely to occur but bank specific variables determine which banks are most likely to be affected. The structure of the banking industry helps explain which countries are likely to face problems under a given set of macroeconomic and bank conditions. A slow and painful reform process, banking sector consolidation and restructuring all contribute.

Not surprisingly the warning indicators are inter-related and, while individual factors may be weakly determined, their joint message tells the story.[18] It is not readily possible to identify key early warning indicators that stand out from the rest. The results suggest that there is a set of intertwined dynamics composed of bank-specific, macroeconomic and structural variables.

The more advanced transition countries, including the new EU members and Croatia, and the rest of the countries in the sample had broadly similar patterns of differences between the sound and problem banks. The more advanced countries however appeared more sensitive to the market forces such as movements on the stock market and dynamics in private lending, the less advanced transition countries on the other hand turned out to be more dependent upon institutional factors such as progress in banking sector reforms.

The validity of the model is reinforced by encouraging in-time and out-of-time predictions with AUROC values of 0.94 and 0.67, respectively. This is even more noteworthy given the substantial volatility in the transition process. In-time, the model managed to recognize at least one distress episode in each of 16 countries that experienced at least one distress episode over the observation period, with only a 10% probability of giving a false alarm. All distress episodes were recognized in 9 out of 16 countries. Out-of-time prediction for the years 2002–2004 revealed that the model was able to capture half of the 16 distress episodes in six out of eight countries experiencing at least one bank distress episode. In four countries – Czech Republic, Hungary, Macedonia and Serbia *all* of the distress episodes were discovered by the out-of-time model. However, none of the distress episodes were recognized in Slovakia and Poland, where the noise in the model was also the highest. Surprisingly the out-of-time model performed excellently for Macedonia, although the country was not included in the estimation as Macedonia experienced its first and only bank distress episode for our sample of banks in 2003.

As many of our indicators are endogenous in the sense that they reflect how banks and the wider economy are responding to adverse circumstances, their role changes as the distress approaches. Thus anyone using the indicators to assess both the probabilities of individual bank distress and systemic problems needs to alter their focus as the problems evolve. Regulators have full access to the indicators they wish to use, as they collect data direct from the banks and do not have to rely on published information as we do. Their ability to predict should therefore be greater. Our findings on the influence of macroeconomic variables have implications for the conduct of macroeconomic policy. As the'Great Moderation' observed for most of the advanced countries is extended to the transition countries so the incidence of banking distress should fall. Sharp cycles contribute to banking distress and in turn the behaviour of banks affects the sharpness of the economic cycle.

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[18] There is considerable colinearity among some of the indicators that thereby limits their individual significance.

Appendix. Variable definitions

Variable	Source
Liquidity	
Volatile short-term liabilities to liquid assets i.e. inverse liquidity ratio: Deposits and short-term funding minus customer deposits to liquid assets	BankScope
Bank deposits to customer deposits	BankScope
Interest expenses to total liabilities	BankScope
Credit risk	
Loans to total assets	BankScope
Loan-loss-provisions to loans	BankScope
Solvency	
Equity-to-total assets	BankScope
Market risk	
Equity investments to total assets	BankScope
Trade-income or other operating income to pre-tax profit	BankScope
Efficiency and profitability	
Cost-to-income ratio: overheads to net interest income plus other operating income	BankScope
Interest income plus other operating income to total assets	BankScope
Macroeconomic and structural indicators	
Private lending to GDP	IMF IFS
GDP real growth	IMF IFS
EURIBOR 3 months	Eurostat
Exchange rate national currency vs US-dollar	IMF IFS
Share of foreign owned banks assets to total banking sector assets	EBRD Transition reports, NCBs, World Bank
Share of state-owned banks assets to total banking sector assets	EBRD Transition reports, NCBs
EBRD banking sector reform index	EBRD Transition reports
Stock market index	Eurostat, national stock exchanges
Herfindahl banking sector concentration index: $\mathrm{HHI} = \sum_{i=1}^{n}(assets_i^2)$	NCBs

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