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Optimal design of early warning systems for sovereign debt crises

Ana-Maria Fuertes *, Elena Kalotychou

Faculty of Finance, Cass Business School, City University, 106 Bunhill Row, London, EC1Y 8TZ, United Kingdom

Abstract

This paper tackles the design of an optimal early warning system (EWS) for sovereign default from two distinct angles: the choice of the econometric methodology and the evaluation of the EWS itself. It compares K-means clustering of macrodata, a logit regression for macrodata, a logit regression for credit ratings, and the combined forecasts from all three methods. The optimal choice of forecast method is shown to depend on the desired trade-off between missed defaults and false alarms. Hence, it is crucial to account for the decision-maker's preferences which are characterized through a loss function and risk-aversion parameter. Recursive forecast combining generally yields a better balance of type I and type II errors than any of the individual forecasting methods, and outperforms the naïve predictions.

JEL classification: C15; C22; C52

Keywords: Country risk analysis; Clustering; Default prediction; Emerging markets; Forecast combining; Logit forecast; Loss function

1. Introduction

The financial turmoil that hit emerging markets in recent decades has triggered the need for accurate country risk assessment. A number of studies have focused on the development of empirical models for explaining and predicting banking and currency crises (Berg & Pattillo, 1999; Frankel & Rose, 1996; Kaminsky & Reinhart, 1999; Kumar, Moorthy, & Perraudin, 2003). As more countries move toward flexible exchange rates, twin crises are becoming less frequent. But sovereign debt crises remain a matter of concern for international financial markets and economic policymakers.

The process of building an Early Warning System (EWS) can be broadly divided into four decision stages: the sample (country and time span), the input variables, the econometric approach, and the evaluation of the EWS in relation to its end use by the decision-maker. The first two have by now received extensive attention in the sovereign default literature. Most studies have focused on identifying the nature–region, country, or period specific–of debt crises, or their main determinants among domestic fundamentals and indicators of the international business-cycle and market sentiment. For this purpose, different classification techniques have been used. However, the

* Corresponding author. Tel.: +44 20 7040 0186; fax: +44 20 7040 8881.
E-mail addresses: a.fuertes@city.ac.uk (A.-M. Fuertes), e.kalotychou@city.ac.uk (E. Kalotychou).

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empirical literature on EWSs with an explicit forecasting objective is relatively young. Scant attention has been paid to forecasting issues and to the design and validation of an EWS tailored to the decision-maker's preferences. The aim of this paper is to contribute to filling this gap.

Several studies have applied discriminant analysis (Frank & Cline, 1971; Taffler & Abassi, 1984), whereas more recent research has been based on panel logit models (Peter, 2002). Non-parametric classification techniques such as clustering and recursive tree analysis, albeit popular in other areas, have received little attention in this context. There is evidence that country credit ratings have predictive power regarding sovereign debt crises and that they Granger-cause sovereign bond spreads (Cantor & Packer, 1996; Reinhart, 2001; Rojas-Suárez, 2001). Moreover, the New Basel Accord allows banks to use internal ratings for calculating capital requirements. The *Institutional Investor* ratings can be regarded as consensus internal ratings from major international banks. The upshot is that it is unclear which method and information set one should adopt in developing an EWS for sovereign default. In this respect, forecast combining may be fruitful.

This paper presents a novel framework for the optimal design of an EWS focusing on methodological issues. The contribution is twofold. First, it assesses alternative forecasting techniques in the light of the decision-maker's degree of risk-aversion towards default. These are: (i) a multivariate logit model based on macrodata, (ii) a univariate logit model based on the *Institutional Investor* ratings, (iii) K-means clustering of macrovariables, and (iv) a combination of the above three forecasting methods (or classifiers) using a parametric regression. In the present context, clustering has not been utilized as yet and issues of forecast combination have barely been addressed. The analysis is based on a sample of 75 emerging/developing economies over the 1983–2000 period.

Second, the paper explores the evaluation of an EWS in relation to the decision-maker's objective function. We show how the latter can be taken into account to choose the classifier and its embedded parameters. The classifiers are shown to have different strengths in terms of missed defaults and false alarms. Furthermore, their forecast ranking is unstable over the holdout years. On the one hand, these findings imply that the user's loss function and degree of risk-aversion are critical inputs in the assessment of an EWS. On the other hand, they motivate forecast combining. It is shown that a relatively better balance of missed default and false alarms is achieved by combining the classifiers. Our framework can be easily adapted to distinct classifiers and loss functions. Finally, as a by-product of our analysis, some lessons emerge for practitioners in the area of sovereign default prediction. First, optimal recursive in-sample calibration of the classifiers is worthwhile. Second, given the persistence of sovereign default events, it seems sensible to gear the out-of-sample assessment of forecast ability toward default *entries* rather than continuing defaults.

Section 2 outlines the background literature. Section 3 describes the methodology and Section 4 introduces the data. Section 5 illustrates several issues regarding the optimal, recursive calibration of classifiers. The forecast combining analysis is presented in Section 6 before concluding.

2. Elements in the design of an optimal EWS

The goal of an EWS is to issue signals of pending debt repayment difficulties. Hence, the variable of interest takes a value of one at year t if a default occurs any time within an h-length window

$$Y_{it} = \begin{cases} 1 & \text{if } d_{i,t+k} = 1 \text{ at any } k = 0, 1..., h-1 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

and the classification problem at hand is formalized as $y_{it}=f(x_{i,t-1})$ where $x_{i,t-1}$ represents the available predictors at $t-1$. The forward-looking variable y_{it} is called the EWS indicator. The warning horizon, h, is the time interval within which the EWS should anticipate the occurrence of a crisis. If the warning horizon chosen is, say, $h=3$ years, then the forecast $\hat{y}_{i,t+1}=1$ indicates that a debt crisis will occur sometime during $[t+1, t+3]$. Currency crisis studies typically focus on $h=2$ years (Berg & Pattillo 1999; Kamin, 1999; Kumar et al., 2003), whereas in the debt crisis literature most studies use $h=1$ year. Choosing the optimal h requires a trade-off. The longer h is, the fewer missed defaults but the more false alarms, and vice versa. Bussière and Fratzscher (2002) show how to find the optimal warning horizon empirically according to a loss function. In order to assess the adequacy of an EWS, the probability forecasts are usually