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How to Evaluate an Early-Warning System: Toward a Unified Statistical Framework for Assessing Financial Crises Forecasting Methods

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predicting currency crises exclusively for South-Asian countries. Besides, the optimal cut-off correctly allows us to identify now on average more than 2/3 of the crisis and calm periods.

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and the crisis probabilities may exist. Nevertheless, this approach is not feasible in our context. Indeed, the accuracy and misclassification measures cannot be employed, as they have been used to identify the optimal cut-off and no other adequate measures have been proposed so far.

5. Also called Correct Classification Frontier, as in [Jorda, Moritz, and Taylor \(2011\)](#).
6. This nonparametric estimator of the AUC criterion has recently been considered by [Jorda, Moritz, and Taylor \(2011\)](#) in the EWS literature, so as to compare different specifications with the random model (AUC=0.5).
7. Contrary to [Jorda, Moritz, and Taylor \(2011\)](#), who rely on a graphical

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11. [Berg and Cooke \(2004\)](#) show that considering a forecast horizon larger than 1 leads to autocorrelation in the crisis variable. This stylized fact is confirmed by [Harding and Pagan \(2006\)](#).
12. The results for the other countries are available on request.
13. In the case of KLR the threshold equals three standard deviations; however, in this case, Taiwan would never register any currency crises, which is historically not accurate. For example, Taiwan was not exempted from the Asian crisis in 1997.

References

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Berg, Andrew, and Catherine A. Pattillo, 1999, "Predicting Currency Crises: The Indicators Approach and an Alternative," *Journal of International Money and Finance*, Vol. 18, pp. 561-586.

[Article](#) [Google Scholar](#)

Berg, Andrew, and Rebecca N. Cooke, 2004, "Autocorrelation Corrected Standard Errors in Panel Probits: An Application to Currency Crisis Prediction," IMF Working Paper.

Berg, Jeroen van den, Bertrand Candelon, and J.P. Jean-Pierre Urbain, 2008, "A Cautious Note on the Use of Panel Models to Predict Financial Crises," *Economics Letters*, Vol. 101, No. 1, pp. 80-83.

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Clark, Todd E., and Michael W. McCracken, 2001, "Tests of Equal Forecast Accuracy and Encompassing for Nested Models," Journal of Econometrics, Vol. 105, No. 1, pp. 85-110.

[Article](#) [Google Scholar](#)

DeLong, Elizabeth R., Dwight M. DeLong, and Daniel L. Clarke-Pearson, 1988, "Comparing the Areas Under Two or More Correlated Receiver Operating Characteristic Curves: A Nonparametric Approach," Biometrics, Vol. 44, No. 3, pp. 837-845.

[Article](#) [Google Scholar](#)

Diebold, Francis X., and Glenn D. Rudebusch, 1989, "Scoring the Leading Indicators," Federal Reserve Bank of St. Louis Review, Vol. 71, No. 3, pp. 331-350.

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Estrella, Arturo, and Gikas A. Hardouvelis, 1991, "The Term Structure as a Predictor of Real Economic Activity," The Journal of Finance, Vol. 46, No. 2, pp. 555-576.

[Article](#) [Google Scholar](#)

Estrella, Arturo, and Mary R. Trubin, 2006, "The Yield Curve as a Leading Indicator: Some Practical Issues," Current Issues in Economics and Finance, Vol. 12, No. 5, pp. 1-7.

[Google Scholar](#)

Frankel, Jeffrey, and George Saravelos, (2010), "Are Leading Indicators of Financial Crises Useful for Assessing Country Vulnerability? Evidence from the

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Press).

Harding, Don, and Adrian R. Pagan, 2006, “The Econometric Analysis of Constructed Binary Time Series,” Working Papers Series 963 (The University of Melbourne).

Hoeffding, Wassily, 1948, “A Class of Statistics with Asymptotically Normal Distributions,” *Annals of Statistics*, Vol. 19, pp. 293–325.

[Article](#) [Google Scholar](#)

Im, Kyung S., Hashem M. Pesaran, and Shin Yongcheol, 1997, “Testing for Unit Roots in Heterogenous Panels,” DAE, Working Paper 9526 (University of Cambridge).

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Kaminsky, Graciela L., Saul Lizondo, and Carmen Reinhart, 1998, "Leading Indicators of Currency Crises," IMF Staff Papers, Vol. 45, No. 1, pp. 1-48.

[Article](#) [Google Scholar](#)

Kapetanios, George, 2003, "Determining the Poolability of Individual Series in Panel Datasets," Working Paper 499.

Kraft, Holger, Gerald Kroisandt, and Marlene Muller, 2004, "Redesigning Ratings: Assessing the Discriminatory Power of Credit Scores Under Censoring," Working Paper.

Kumar, Mohan, Uma Moorthy, and William Perraudin, 2003, "Predicting

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Paper.

Martinez-Peria, Maria-Soledad, 2002, "A Regime-Switching Approach to the Study of Speculative Attacks: A Focus on EMS Crises," Empirical Economics, Vol. 27, No. 2, pp. 299-334.

[Article](#) [Google Scholar](#)

Maddala, Gangadharrao S., and Shaowen Wu, 1999, "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test," Oxford Bulletin of Economics and Statistics, Special Issue, pp. 631-652.

Mitchener, Kris James, and Marc D. Weidenmier, 2006, "The Baring Crisis and the Great Latin American Meltdown of the 1890s," NBER Working Paper No. 12402

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Stein, Roger M., 2005, "The Relationship Between Default Prediction and Lending Profits: Integrating ROC Analysis and Loan Pricing," Journal of Banking and Finance, Vol. 29, pp. 1213–1236.

[Article](#) [Google Scholar](#)

Williams, Rick L., 2004, "A Note on Robust Variance Estimation for Cluster-Correlated Data," Biometrics, Vol. 56, No. 2, pp. 645–646.

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Wright, Jonathan H., 2006, "The Yield Curve and Predicting Recessions," Finance and Economic Discussion Series No. 7 (Federal Reserve Board).

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Association Congress (Glasgow), the 2010 Econometric Society World Meeting (Shanghai), the 2010 meeting of the Association Francaise de Sciences Economiques (Paris), the 2010 business cycle meeting at Eurostat (Luxemburg) and the 2009 MIFN meeting (Luxemburg) for their questions and reactions. The usual disclaimers apply.

Electronic supplementary material

[Supplementary Tables](#)

Appendices

Appendix I

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$$\hat{\mathbb{V}}_{(2,2)} = (T_1)^{-1} \hat{S}_1 + (T_0)^{-1} \hat{S}_0, \quad (\text{A.3})$$

where T_1 (respectively T_0) is the number of crisis (respectively calm) periods in the sample, and \hat{S}_1 (respectively \hat{S}_0) denotes the estimated variance for the crisis (respectively calm) periods.

$$\hat{S}_1 = \frac{1}{T_0^2(T_1 - 1)} \sum_{i:y_i=1} \left(\begin{aligned} &\left[\sum_{j:y_j=0} K(\hat{p}_j, \hat{p}_i) - T_0 \times AUC_1 \right]^2 \\ &\left[\sum_{j:y_j=0} K(\hat{p}_j, \hat{p}_i) - T_0 \times AUC_1 \right] \\ &\times \left[\sum_{j:y_j=0} K(\hat{p}_j, \hat{p}_i) - T_0 \times AUC_2 \right] \\ &\left[\sum_{j:y_j=0} K(\hat{p}_j, \hat{p}_i) - T_0 \times AUC_1 \right] \end{aligned} \right)$$

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$$\hat{S}_0 = \frac{1}{T_1^2(T_0 - 1)} \sum_{j:y_j=0} \left(\begin{aligned} &\left[\sum_{i:y_i=1} K(\hat{p}_j, \hat{p}_i) - T_1 \times AUC_1 \right]^2 \\ &\left[\sum_{i:y_i=1} K(\hat{p}_j, \hat{p}_i) - T_1 \times AUC_1 \right] \\ &\times \left[\sum_{i:y_i=1} K(\hat{p}_j, \hat{p}_i) - T_1 \times AUC_2 \right] \\ &\left[\sum_{i:y_i=1} K(\hat{p}_j, \hat{p}_i) - T_1 \times AUC_1 \right] \\ &\times \left[\sum_{i:y_i=1} K(\hat{p}_j, \hat{p}_i) - T_1 \times AUC_2 \right] \\ &\left[\sum_{i:y_i=1} K(\hat{p}_j, \hat{p}_i) - T_1 \times AUC_2 \right]^2 \end{aligned} \right), \quad (A.5)$$

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Following their results, we identify crisis periods using the KLR modified pressure index (KLRm), which, unlike the KLR index, also includes interest rates:

$$KLRm_{it} = \frac{\Delta e_{it}}{e_{it}} - \frac{\sigma_e}{\sigma_r} \frac{\Delta r_{it}}{r_{it}} + \frac{\sigma_e}{\sigma_{ir}} \Delta ir_{it}, \quad (A.7)$$

where e_{it} denotes the exchange rate (that is, units of country i 's currency per U.S. dollar in period t), $r_{n,t}$ represents the foreign reserves, while ir_{it} is the interest rate. Meanwhile, the standard deviations σ_X are actually the standard deviations of the relative changes in the variables, $\sigma(\Delta X_{it}/X_{it})$, where X denotes each variable separately, including the exchange rate and the foreign reserves, with $\Delta X_{it} = X_{it} - X_{i,t-6}$. For the interest rate, σ_{ir} is the standard deviation of the absolute changes in interest rate. For both subsamples, the threshold equals two standard deviations above the mean:^{[13](#)}

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serves as the crisis dummy variable taking the value of 1 if there will be a crisis in the following 24 months and 0 otherwise:

$$C24_{it} = \begin{cases} 1 & \text{if } \sum_{j=1}^{24} Crisis_{it+j} > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{A.10}$$

At the same time, several explanatory variables from three economic sectors are considered ([Lestano and Kuper, 2003](#)) on a monthly frequency and denoted in U.S. dollars:

- 1 *External sector*: the one-year growth rate of international reserves, the one-year growth rate of imports, the one-year growth rate of exports, the ratio of M2 to foreign reserves, and the one-year growth rate of M2 to foreign reserves.

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deposit rate, the first difference of the industrial production index, and yield spread are the least correlated ones with all the other indicators for all the 12 countries. The competing models are defined such that no couple of indicators is correlated in more than four countries. We hence identify the leading indicators by minimizing the AIC and BIC information criteria of the pooled panel data models, that is, growth of international reserves, growth of exports, growth of domestic credit over GDP, first difference of lending over deposit rate, first difference of industrial production index, and yield spread. The missing values through the series are replaced using cubic splines interpolation, but when the series revealed missing values at the beginning of the sample, such as “the one-year growth of terms of trade” or “yield spread,” the corresponding observations are dropped from the analysis, leading to an unbalanced panel framework. [Table 8](#) shows the period covered by the leading indicators for each of the 12 countries.

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which is a robust variance estimator for the time-series model.

The main advantage of this sandwich method is that it can also be applied in the case of grouped data, as in our case. It is important to note that in the current situation, each country from a cluster is a group of time-series observations that are correlated. Thus, the observations corresponding to a country are not treated as independent, but rather the countries themselves which form the clusters, are considered independent. Therefore, instead of using $g_t(\beta)$, we use the sum of $g_t(\beta)$ for each country, while T is replaced by the number of countries in a cluster. These changes ensure the independence of so-called superobservations entering the formula ([Gould and others, 2005](#)).

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