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Forecasting financial crises and contagion in Asia using dynamic factor analysis

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ABSTRACT

In this paper we use principal components analysis to obtain vulnerability indicators able to predict financial turmoil. Probit modelling through principal components and also stochastic simulation of a Dynamic Factor model are used to produce the corresponding probability forecasts regarding the currency crisis events affecting a number of East Asian countries during the 1997–1998 period. The principal components model improves upon a number of competing models, in terms of out-of-sample forecasting performance.

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1. Introduction

The currency and financial turmoil affecting the Latin American countries during the 1994 period and the East Asian emerging market economies during the 1997–1998 period has attracted particular attention by both academics and policymakers. In particular, these crises have fueled a new variety of theories, also known as third generation currency crisis models, which focus on moral hazard and imperfect information. The emphasis is on excessive booms and busts in international lending. In particular, throughout most of the 1990s, massive capital inflows had been pouring in the East Asian region, mainly in the form of bank lending. Most of the foreign borrowing in these economies was short-term with Japan being the country with the largest exposure. Therefore, the focus of this paper is to examine the role played by the financial capital markets in propagating balance of payment crises across Indonesia, Malaysia, Philippines, Korea, Thailand, during the 1997–1998 crisis period. Work based on third generation currency crisis models has motivated various reports from the IMF on the "architecture" of the international financial system, where the emphasis is on the importance of sound debt and liquidity management in helping to prevent external crises. For instance, the IMF report on "Debt- and Reserve-Related Indicators of External Vulnerability", published in 2000 stresses the importance, for Central Banks, of holding foreign reserves in order to maintaining liquidity and allowing time to absorb shocks in situations where access to borrowing is curtailed or very costly. It is, therefore, important to monitor a number of vulnerability indicators (such as the ratio of either the total stock of external debt to the stock of international reserve or the ratio of the short term external debt to the stock of foreign reserves) to examine whether they can be considered as accurate leading indicators of currency crises, as suggested by the Early Warning System literature (EWS).

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Currency turbulence in this paper is proxied by using the Exchange Market Pressure Index (*EMP*). This index was first used by Girton and Roper (1977), and subsequently by a number of authors in the context of exchange rate crises (see Tanner, 2002, for a recent use). Girton and Roper use a simple monetary model to derive a definition of *EMP* as the sum of exchange rate depreciation and reserve outflows, scaled by base money. This index summarizes the flow of excess supply of money (i.e., the difference between the growth rates of the domestic component of the monetary base and money demand) in a managed exchange rate regime, reflected in both exchange rate and reserve movements. Hence an increase in the value of a country's *EMP* indicates that the net demand for that country's currency is weakening and hence that the currency may be liable to a speculative attack or that such an attack is already under way.

There are two main methods used in the EWS literature to predict currency market turbulence. One method relies on the signal approach proposed by Kaminsky et al. (1998), and the other one relies on "parametric" modelling, given that it is based upon limited dependent variable regression modelling (see the study of Frankel and Rose, 1996, among the others). The EWS modelling approach we follow in this paper is the "parametric" one, and it is based upon the investigation of the out-of-sample predictive performance of a composite leading indicator via regression analysis. In particular, the composite indicator is constructed by extracting common factors from the Bank for International Settlements, BIS, dataset which gives detailed information on the composition of external debt. To our knowledge this dataset has not been previously exploited to construct composite leading indicators of a currency crisis event, defined in terms of the *EMP* index[1]. The choice of using disaggregated data on external debt is based upon the suggestion given by various studies on financial contagion. The literature on financial contagion puts the emphasis on the role of the geographical composition of external debt (e.g., the common lender channel), and on the maturity mismatch in explaining the spread of the crisis hitting one country to other countries. Given that BIS external debt data are available for a relatively long data span (starting from 1983) only at low frequency (bi-annual basis), the number of cross sections exceed the time series observations, hence it is not practical to use standard state space model methods to extract factors (especially, when one is interested in recursive estimation in order to produce out-of-sample predictions for the forecast evaluation period). Therefore, we use factors extraction based on principal components analysis as suggested by Stock and Watson (2002)[2].

Furthermore, contrary to previous studies which have only explored the out-of-sample forecasting performance of the composite indicator, we also assess which group of variables (say, short term debt) play an important role in predicting out-of-sample the crisis event through the composite leading indicator. The use of principal components for the purpose of constructing leading indicators of currency crisis has already been put forward by Cipollini and Kapetanios (2003) who produce out-of-sample point forecast of the *EMP* index in East Asian countries for the 1997–1998 period, and also by Inoue and Rossi (2008) and by Jacobs et al. (2008). While the probability forecast of currency crisis events in the study of Inoue and Rossi (2008) rely on modelling the conditional second moments of the nominal exchange rate through principal components, the probability forecasts we produce are obtained by modelling the conditional first moment of the *EMP* index through common factors[3]. As for the out-of-sample probability forecasts, Jacobs et al. (2008) focus only on one year, 2002, (where there is no evidence of particular turbulence in the East Asian currency markets) and there is no comparison with forecasts produced by other benchmark models, including an *AR* for the *EMP*.

Our contribution to the EWS literature is twofold. First, we explore the out-of-sample forecast performance of principal components extracted from a novel dataset (based upon disaggregated data on external debt, deflated by the stock of international reserves). Second, we to explore the role not only of static factors (as previously done in Inoue and Rossi (2008) and in Jacobs et al. (2008), although their focus on a different dataset from which extracting the principal components), but also the role of dynamic factors in forecasting out-of-sample *EMP*. More specifically, we use stochastic simulation of the Dynamic Factor model, (*DF*), following the suggestions of Forni et al. (2005) on how to retrieve a single common shock (e.g. the dynamic factor), interpreted as a regional vulnerability indicator. The probability forecast accuracy is assessed by using both the Kuipers Score and the Matthews correlation coefficient.

The outline of the paper is as follows. Section 2 reviews the EWS literature and the financial contagion studies, respectively. Section 3 describes the empirical methodology. Section 4 describes the dataset and the empirical analysis. Section 5 concludes.

2. Background literature

As already mentioned in the Introduction, the first method used in the EWS literature is the signal approach proposed by Kaminsky et al. (1998) who monitor the evolution of several indicators. If any of the macro-financial variables of a specific country tends to exceed a given threshold during the period preceding a crisis, then this is interpreted as a warning signal that a currency crisis in that specific country may take place within the following months. The threshold is then adjusted to balance type I errors (that the model fails to predict crises when they actually take place) and type II errors (that the model predicts crises which do not occur). Kaminsky (1999) and Goldstein et al. (2000) base their prediction of a crisis occurring in a specific country by monitoring the evolution not only of a single macro-indicators, but also on a composite leading indicator, which aggregates different macro-

[1] The use of annual data by Frankel and Rose (1996) allows the exploitation of information on the composition of external debt. However, Frankel and Rose (1996) focus on predicting large nominal exchange rate depreciations and not crisis events defined in terms of the EMP index.

[2] The Stock and Watson (2002) method is a time-domain based approach. In Forni et al. (2000) the factor extraction is obtained using a frequency domain based approach. Finally, Kapetanios and Marcellino (2003) use an approach based upon a state space model.

[3] The Inoue and Rossi (2008) probability forecasts are for crisis events defined in terms of nominal exchange rate depreciations bigger than 20%. We argue that this type of currency crisis considered does not include speculative attacks successfully warded off by the authorities through reserve sales.

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