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Currency crisis early warning systems: Why they should be dynamic

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ABSTRACT

Traditionally, financial crisis Early Warning Systems (EWSs) have relied on macroeconomic leading indicators when forecasting the occurrence of such events. This paper extends such discrete-choice EWSs by taking the persistence of the crisis phenomenon into account. The dynamic logit EWS is estimated using an exact maximum likelihood estimation method in both a country-by-country and a panel framework. The forecasting abilities of this model are then scrutinized using an evaluation methodology which was designed recently, specifically for EWSs. When used for predicting currency crises for 16 countries, this new EWS turns out to exhibit significantly better predictive abilities than the existing static one, both in- and out-of-sample, thus supporting the use of dynamic specifications for EWSs for financial crises.

1. Introduction

The recent subprime crisis has renewed the interest of both policymakers and academics in Early Warning Systems (EWSs). These models are constructed so that they should be able to set off an alarm before the occurrence of a financial crisis (banking, currency, debt, etc.), thereby providing authorities with sufficient time to implement adequate rescue policies in order to avoid or at least attenuate the adverse effects of the turmoil. Unfortunately, existing EWSs remained silent at the brink of the recent financial crisis, leading researchers to question their usefulness (see Rose & Spiegel, 2012). One of the reasons for their silence is the fact that EWS models are fundamentally static, in the sense that they explain the occurrence of crises only through changes in exogenous, macroeconomic variables. This paper contributes to the existing literature on currency crises by developing a new generation of EWSs, which takes the endogenous dynamic of this phenomenon into account.[1]

The objective of an EWS model is to detect accurately the occurrence of a crisis, which is represented by a binary variable which takes the value of one when the event occurs, and the value of zero otherwise. Given the dichotomic character of the crisis indicator, traditional econometric time series techniques cannot be implemented directly. In this context, the attempt to construct an EWS was based upon a signaling approach (Kaminsky, Lizondo, & Reinhart, 1998). Using a large set of potentially informative variables, Kaminsky et al. (1998) identified thresholds beyond which each of these leading indicators signals a crisis.

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[1] This dynamic model can also be implemented in the case of other types of financial crises.

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The properties of such an EWS clearly depend on these cut-off points. Kaminsky et al. (1998) estimated each of these thresholds to be the value that minimized the ratio of the number of crises missed to the number detected correctly, which is also known as the noise-to-signal ratio.[2] Once the variable-specific thresholds have been determined, an aggregate indicator of an impending crisis is constructed as a weighted combination of these variables. The weights correspond to the inverse of the associated noise-to-signal ratio. As the economy approaches a crisis period, this EWS should exhibit a positive trend, i.e., indicate an increase in the probability of occurrence of a crisis.

A second class of EWS models began to emerge with the work of Berg and Pattillo (1999). These authors argue that it is impossible to use statistical methods to make inferences in the signaling framework, and opt for a static panel probit EWS. In their framework, the binary crisis indicator is treated as an endogenous variable which is explained by a set of macroeconomic variables. Furthermore, it becomes possible to test the significance of leading indicators of currency crises formally. Evaluation criteria such as the quadratic probability score (QPS) and the log probability score (LPS) indicate that their EWS exhibits better forecasting abilities (both in- and out-of-sample) than the EWS proposed by Kaminsky et al. (1998).

Given that the estimation method for panel discrete-choice variables is quite standard and is available in almost all econometric software, the panel EWS framework has been implemented extensively in applied studies. Several extensions have been proposed. Kumar, Moorthy, and Perraudin (2003) advocate the use of panel logit models instead of panel probit models. Bussiere and Fratzscher (2006) suppose that a specific post-crisis regime may occur, and therefore define the crisis indicator as a variable with three states instead of two, thus estimating a multinomial logit EWS. Falcetti and Tudela (2006) estimate a binary model in a maximum-simulated likelihood framework, including the lagged crisis indicator on the right-hand side. Berg, Candelon, and Urbain (2008) analyse the presence of country clusters, i.e., groups, and their consequences for an EWS.

One feature that the above-mentioned EWSs have in common is the fact that they are static,[3] i.e., they assume that the probability of a crisis depends only on a set of macroeconomic variables which reflect the economic policies being implemented. This assumption is not supported by empirical studies, which show that the longer a country has been in a crisis period, the higher the probability that it will exit the crisis, whatever the political reaction is (see Tudela, 2004). Neglecting the impact of endogenous crisis persistence may lead to an incorrect evaluation of the weight of leading macroeconomic indicators, and hence to the implementation of inadequate policies.

The present paper proposes a new generation of EWSs which reconcile the binary-choice property of the crisis variable with the persistence dimension of the crisis process. The specifications considered include both macroeconomic variables, i.e., the source of exogenous crisis persistence, and the dynamics of the crisis, i.e., the source of endogenous persistence.

The contribution of this paper to the EWS literature is twofold: first, we propose new dynamic EWS models, and second, we scrutinize their forecasting abilities accurately. Intuitively, accounting for crisis dynamics may improve the fit of the model, as crises are persistent events (that is, they last more than one period). We then go one step further and check whether these new EWSs exhibit better forecasting abilities than the existing models. For this, we gauge both the in-sample and out-of-sample forecasting performances of static and dynamic discrete-choice EWSs. As was argued by Candelon et al. (2012), most of the EWS literature focuses on identifying which leading indicators should be included in such a model, while the evaluation of EWSs is generally based on 'second-best' criteria, such as the noise-to-signal ratio, QPS, LPS. We are the first to rely on the evaluation methodology recently proposed by Candelon et al. (2012), i.e., the area under the *ROC* curve (*AUC*) criterion, and the associated *ROC* test, in our quest for the best-performing discrete-choice EWS.

The dynamic EWS framework we propose has several advantages. First, it allows us to easily estimate and compare several binary EWS specifications, including the static one. To do this, we implement the exact maximum likelihood estimation method proposed by Kauppi and Saikkonen (2008).[4] Second, it can be used to construct EWSs for any type of crisis, not just currency crises, as in our application. Furthermore, we extend this time series framework to a dynamic fixed effects panel EWS by including the score correction proposed by Carro (2007).[5]

As will be seen, the dynamic model with the lagged binary dependent variable which we propose outperforms (both in-sample and out-of-sample) the specifications considered in the previous EWSs, and the traditional static logit in particular. Most importantly, our new EWS has good out-of-sample forecasting abilities, not only for one period ahead, but also for a longer 6-month forecast horizon. This is an important advantage from the policymaker's point of view, as an EWS is supposed to give regulators sufficient time to take steps to prevent a crisis, or at least to

2 Alternative estimation methods of this threshold are also available (see Candelon, Dumitrescu, & Hurlin, 2012).

3 An alternative strategy for building EWSs by integrating crisis dynamics via Markov-switching models has also been proposed (see Abiad, 2003, *inter alia*), but these models rely on continuous market pressure indices (a weighted average of macroeconomic variables that indicate balance-of-payment vulnerability), and do not consider the binary crisis indicator as the dependent variable. Since the superior forecasting abilities of static discrete-choice EWSs relative to Markov-switching ones have been emphasized by Candelon, Dumitrescu, and Hurlin (2009), we do not consider Markov-switching EWSs in this paper.

4 Kauppi and Saikkonen (2008) implement this estimation method for business cycle analysis, and, to the best of our knowledge, it has not previously been considered in the financial crisis literature. The only existing dynamic EWS based on a discrete-choice specification is that proposed by Falcetti and Tudela (2006), who consider the case where the previous regime can affect the current crisis probability, and use a less straightforward simulated maximum likelihood estimation method. In contrast, our framework allows for different specifications of the dynamics of the crisis. It can be written easily in most common econometric software, and is not time-consuming (results are obtained in a few seconds).

5 All Matlab code is available from the authors upon request.