Predicting sovereign debt crises using artificial neural networks: A comparative approach

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Abstract

Recent episodes of financial crisis have revived interest in developing models able to signal their occurrence in timely manner. The literature has developed both parametric and non-parametric models, the so-called *Early Warning Systems*, to predict these crises. Using data related to sovereign debt crises which occurred in developing countries from 1980 to 2004, this paper shows that further progress can be achieved by applying a less developed non-parametric method based on artificial neural networks (ANN). Thanks to the high flexibility of neural networks and their ability to approximate non-linear relationship, an ANN-based early warning system can, under certain conditions, outperform more consolidated methods.
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1. Introduction

The aim of this paper is to further develop the Early Warning System (EWS) literature on financial crisis. In particular, it presents a less explored non-parametric method, i.e. the artificial neural network (ANN), and tests its capacity to predict crises imminence. The paper shows, with an empirical application to sovereign debt default in developing countries, that a well-developed ANN can outperform both parametric and non-parametric traditional methods in emitting timely signals of crisis episodes.

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Financial crises that occurred in emerging countries in the 1990s have revived theoretical and empirical interest in understanding their causes and consequences, as well as in developing statistical and econometric models able to signal their occurrence in timely manner.[1]

According to Krugman (1999, 2001) and Kaminsky (2003), economic theory has developed three generations of models explaining financial crises: the "first" and "second generation" models focus on currency crises, while the "third generation" ones cover a wider variety of crises and are better able to explain episodes that occurred in the late 1990s. In the "first generation" models, poor economic policies conflict with the goal of a fixed exchange rate and produce a continuous loss in foreign exchange reserves. Once reserves have fallen below a critical level, the authorities are forced to abandon the exchange rate peg. The building blocks of "second generation" models are the existence of multiple exchange rate equilibria and self-fulfilling speculative attacks. Even in the presence of sound economic policy, a government may consider the costs of maintaining a fixed exchange rate to be excessively high once the currency is subject to speculative attack. If investors doubt the authorities' commitment to maintaining the peg and start to sell the currency, the government is induced to abandon the peg, which would otherwise have been sustainable. In this sense, speculative attacks are self-fulfilling. "Third generation" models were developed after the Asian crises, and they shifted the focus from public to private imbalances because public finances in those countries were quite sound, whilst those of the corporate and banking sectors displayed excesses. The literature analyses not only currency crises but also bank and "twin crises" (currency and banking crises), balance of payment crises, and sovereign debt crises. The theoretical underpinnings of third generation models vary: the moral hazard problem due to an implicit government guarantee which, together with poor regulation, induces over-landing and over-investment; the balance sheet effect due to a mismatch between assets and liabilities; a self-fulfilling liquidity run when (government, bank or corporate) debt has short-term maturity; a sudden stop to capital inflow due to external shocks. In all these cases the currency crisis is "more a symptom than a fundamental aspect of these crises",[2] and government, bank, corporate and currency crises are often related each other.

In the past decade, many empirical studies have sought to develop models able to emit timely signals of the occurrence of a financial crisis, the so-called Early Warning Systems (EWSs). Using statistical and econometric techniques, these models are applied to predict the likelihood of financial crises, using for the purpose a large number of indicators related to internal and external factors, as well as social and political conditions. According to the type of approach adopted, models can be classified between parametric and non-parametric.[3] Frankel and Rose (1996) and Kaminsky et al. (1998) (KLR) are the seminal papers in the two classes of approaches applied to currency crisis prediction.

In parallel with the previous literature on currency crises, the empirical literature on debt crises, which is comparatively rather small, can also be classified between parametric and non-parametric. Detragiache and Spilimbergo (2001) and Ciarlone and Trebeschi (2005) have used parametric models,[4] while Manasse et al. (2003) have used both parametric and non-parametric approaches to develop an Early Warning System for debt crises.[5] In the latter paper the authors

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[1] For a review of this topic see Roubini and Setser (2005). Sturzenegger and Zettelmeyer (2006) concentrate their discussion on sovereign default.

[2] Krugman (2001, p. 8).

[3] For a review of different approaches see Abiad (2003), Berg et al. (2004) and Ciarlone and Trebeschi (2004).

[4] A probit and a multinomial logit, respectively.

[5] They use logit and classification and regression tree analysis (CART).