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Review of the BSP Early Warning System for Currency Crisis

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Introduction

An early warning system (EWS) is among the broad range of monitoring tools that could be used to assess the overall health of the financial system. It is comprised of several indicators that provide information on macroeconomic and financial conditions, as well as models that predict potential future crises. An efficient EWS is able to detect the buildup of vulnerabilities over time and to identify the possible sources of stress (Krishnamurti & Lee, 2014).

The Current BSP EWS

The current EWS of the BSP was developed following the 1997/1998 Asian Financial Crisis, with the objective of monitoring vulnerabilities and managing risks in the financial system that could lead to a currency crisis as cited by Cintura, et al. (2005). This system adopted the signal approach model of Kaminsky, Lizondo, and Reinhart (1998), which has four components: crisis definition, leading indicator selection, signaling horizon, and threshold setting and monitoring.

Crisis definition determines the periods that will be recognized as crisis incidents. For the EWS model on currency crisis, the exchange market pressure (EMP) index is used to identify crises occurrences. It is a function of the monthly percent changes in the gross international reserves and nominal exchange rate, scaled by the ratio of the standard deviations of the two series. A period is considered a crisis event if the value of EMP index is more than 1.5 standard deviations away from the historical mean of the index.

Once the definition of the crisis has been determined, the next step is to identify the set of indicators that could generate signals of potential vulnerabilities. The leading indicators may relate to certain sectors of the economy or a risk component of a particular sector. Currently, there are 24 leading indicators in the BSP EWS. These are grouped into six sectors: external, monetary, financial, real, fiscal, and the global economy. Vulnerability indices are then computed for each sector as well as the optimal threshold values for each indicator and index. The BSP EWS uses a grid search approach in identifying the optimal thresholds by estimating the values at different percentiles, either from the 5th to 20th percentile and/or the 80th to 95th percentile depending on the information or tail risk that the variable is tracking, and then selects the threshold with the most accurate prediction.

To examine an indicator's ability to predict future crises, the current EWS model uses the Noise-to-Signal Ratio (NTSR) which is a measure that quantifies the "noisiness" of a leading indicator based on the signals it issues. More specifically, it represents the ratio between false alarms (noise) and correct crisis alerts (signal). In theory, lower

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values of the NTSR are preferred as a high NTSR indicates that the indicator is generating too many false alarms or too few correct signals (Kaminsky et al., 1998).

In the initial development of the EWS Currency Crisis model for the Philippines in 2002, the best performing indicators in predicting a currency crisis (i.e., lower NTSR) were the deviation from trend of the real effective exchange rate, money multiplier, year-on-year change in commercial banks' real deposits, real gross domestic product (GDP) growth, and the ratio of government consumption to GDP. Meanwhile, as a sub-index, the external sector index proved to be the best forward-looking sectoral indicator for a currency crisis. Overall, the initial BSP EWS had high in-sample accuracy of 90 percent for the period 1980 to 2001 with an 18-month signaling horizon. This version was then updated in 2008 by refining some of the variables, specifically those in the financial sector, as well as re-estimating the thresholds.

Proposed Review of the BSP EWS

Given the changes in market behavior and developments in the macro-financial landscape over time, the BSP EWS model has to be revisited and reviewed to further enhance its predictive capacity. In particular, there are new variables that may better reflect current market dynamics which can be considered as possible leading indicators. Moreover, recent studies have proposed alternative performance measures that can be used to identify better leading indicators.

Twelve new indicators are considered for the period January 1980 to September 2020 (**Table 1**) in the review of the BSP EWS.[2] Threshold values for each indicator are estimated at different percentiles and are then ranked according to the resulting NTSR of each threshold to identify the optimal threshold value. A lower NTSR generally signifies better performance in predicting a crisis over the signaling horizon. Similar to the EMP index, indicator values that exceed their optimal thresholds will issue a signal of an impending crisis.

Table 1. List of Potential New Leading Indicators

Indicator	Source
External sector	
• Import Cover	BSP
• USDPHP spot rate, year-on-year growth	BSP
• Gross international reserves, year-on-year growth	BSP
Financial sector	
• Lending rate-savings deposit rate spread	BSP
• 3-month PH-US interest rate differential	BSP and FRED
• PSE index price-earnings ratio	CEIC
Fiscal sector	
• Government expenditure, year-on-year growth	CEIC
• Fiscal Balance, year-on-year growth	CEIC
Global Economy	
• Japan Industrial Production Index, year-on-year growth	CEIC
• US Industrial Production Index, year-on-year growth	CEIC
• EU Industrial Production Index, year-on-year growth	CEIC
• US retail sales, year-on-year growth	CEIC

Note: FRED = Federal Reserve Economic Data, Federal Reserve Bank of St. Louis.

[2] The paper originally considered 33 new indicators based on the initial survey of related literature. Other indicators, however, had to be dropped due to data constraints.

Boonman, Jacobs, Kuper, and Romero (2019) highlighted the importance of minimizing errors, such as missed crises and false alarms, given the significant economic costs of policy errors that were based on model mispredictions. Policy adjustments based on false alarm signals could unduly dampen domestic economic growth, while failure to react pre-emptively owing to missed crises signals could lead to overheating, resulting in significant economic losses down the road. Aside from the NTSR (i.e., those with NTSR values below 1), other metrics may be used to examine predictive performance, such as the area under the receiver operating characteristic curve (AUROC) and the usefulness index.

In contrast to the NTSR, the AUROC has the ability to distinguish between good signals and false alarms for all possible thresholds instead of a single threshold. It maps out the rate of true positives or the correctly classified crises against the rate of false positives or the false alarms for all possible thresholds.

Moreover, an informative and discerning leading indicator will have an AUROC closer or equal to 1, while an uninformative indicator will have an AUROC closer to 0.5 (Caggiano, Calice, & Leonida, 2014).

Meanwhile, the usefulness index considers the policy maker's preference (θ) between the probability of getting false alarms (type II error) and of missing crises (type I error), as well as the benefit of getting signals from an indicator instead of completely ignoring it. A higher value of θ indicates that a policymaker is more averse to missing a crisis than receiving false alarm. In particular, Alessi and Detken (2011) defines the loss function and the usefulness of the indicator as:

$$L = \theta Type\ I\ error + (1-\theta) Type\ II\ error$$
$$Usefulness = \text{minimum}[\theta; 1-\theta] - L$$

An indicator is deemed useful, that is having a usefulness index greater than zero, if it produces a loss (L) that is lower than the minimum of θ and $(1-\theta)$. On one hand, when θ is less than 0.5, an indicator will only be considered if it provides a loss that is lower than θ, else the policymaker would be better off by ignoring it. On the other hand, when θ is greater than 0.5, an indicator will only be useful if it produces a loss lower than $(1-\theta)$, else the policymaker would simply

Table 2. Best Performing Leading Indicators (Current BSP EWS model)

Indicator	AUROC	Optimal Threshold (lowest NTSR)				Optimal Threshold (highest usefulness index)			
		Pctl	Value	NTSR	U	Pctl	Value	NTSR	U
REER	0.7357	95	7.18	0.0313	0.1171	80	3.28	0.2112	0.2210
FL/FA	0.8066	95	2.38	0.0762	0.0812	80	1.74	0.1185	0.3100
91-day T-bill	0.7359	95	23.16	0.0573	0.1036	85	15.87	0.1317	0.2242
Time deposit rate	0.8392	95	20.56	0.0512	0.0990	80	14.12	0.0875	0.3409

Table 3. Best Performing New Leading Indicators

Indicator	AUROC	Optimal Threshold (lowest NTSR)				Optimal Threshold (highest usefulness index)			
		Pctl	Value	NTSR	U	Pctl	Value	NTSR	U
P/E ratio	0.7336	95	21.91	0.0648	0.1753	85	20.37	0.1964	0.2344
Import cover	0.8228	5	1.30	0.0000	0.1319	20	2.50	0.1201	0.3046
Lending-deposit spread	0.7212	95	14.98	0.0113	0.1195	80	9.24	0.2233	0.2048
PH-US yield spread	0.6847	95	16.81	0.0802	0.0910	80	9.06	0.2736	0.1756

Note: Pctl is the optimal percentile; value is the corresponding threshold value of the optimal percentile; NTSR and U are the estimated noise-to-signal ratio and usefulness index of the optimal percentile, respectively.

assume that the indicator will always produce a signal (Alessi & Detken, 2011).

Based on the three evaluation methods, **Table 2** shows that the best performing indicators in the current BSP EWS are the real effective exchange rate (REER), ratio of foreign liabilities to foreign assets (FL/FA), 91-day Treasury bill rate (Tbill), and time deposit rate (all maturities). Compared to the initial model in 2003, only the real effective exchange rate continued to be among the top performing indicators given the updated data. In addition to the top indicators, this study also finds that having a neutral stance (i.e., $\theta = 0.5$) between type II and type I errors provided the highest usefulness index values (U).

Among the 12 new indicators considered in the study, the top four indicators in predicting a possible currency crisis are the price-earnings (P/E) ratio, import cover, spread between lending and deposit rates, and the 3-month PH-US interest rate differential (**Table 3**). Since they are components of the EMP index, the international reserves and nominal USD-PHP exchange rate also proved to be good indicators to predict a currency crisis, with an NTSR of 0.0337 and 0.0971, respectively. Meanwhile, the Japan and EU Industrial Production Indices, US retail sales, and government expenditure provided the least information for the currency crisis model.

Possible Future Improvements

This review of the BSP EWS also recommends possible improvements moving forward, namely, addressing the data gaps, using mixed frequency data, revisiting the crisis definition, and implementing new modelling techniques. In particular, data for some indicators mentioned in the literature, such as those for nonbank sectors, are still limited. A possible solution is to use a mix of indicators with different frequencies which can further improve the forecast performance of the EWS. This, however, is only applicable to information that can be extended to periods earlier than 1998 given that there are only few crisis signals after 1997. Hence, it is also recommended to revisit the crisis definition or implement other modelling techniques, from conventional statistics to recent machine learning techniques, to address this issue.

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