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Early warning systems for currency and systemic banking crises in Vietnam

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ABSTRACT

This paper introduces a new early warning system (EWS) for currency and systemic banking crises in emerging and frontier emerging markets, which combines the methods of Signal, Logit/Probit, BMA, and 2SLS. We apply this framework to the case of Vietnam, a fast-growing and leading frontier emerging market. Using data covering the period from January 2002 to December 2016, our EWS suggests a low crisis probability for the 2017–2018 period. The empirical results also reveal the importance of eight key indicators, namely securities index, real effective exchange rate, exports, M2/reserves, bank deposits, reserves, M2 multiplier and the impact of the 2008–2009 global financial crisis in the success of the new EWS. Our results support the earlier findings on i) the impact of dollarisation on currency crises and ii) the impact of the global financial crisis on both currency and systemic banking crises in Vietnam.

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1. Introduction

Over the past three decades, the world has witnessed an unprecedented increase in currency and systemic banking crises, such as the collapse of the European monetary system in 1992–1993, Mexican crisis in 1994–1995, Asian Financial Crisis in 1997–1998, Argentina crisis in 2002 and the recent global financial crisis (GFC) in 2008–2009. In total, there were 147 systemic banking crises occurred in all countries around the world, with average productivity losses up to 23% of GDP and significant fiscal costs to cope with the aftermath of the crisis in the 1970s up to 2011 (Laeven & Valencia, 2012). Similarly, currency crises also caused considerable output losses, ranging from an average of 3% up to 15% of GDP (Hutchison et al., 2010). It can be seen that the damage caused by the crises and the costs of dealing with the consequences are extremely severe and their impact is overly contagious with quickly and vigorously spreading to other countries, especially after the increased financial connectedness in the last two decades. Therefore, the development of early warning systems (EWS) for currency crises and systemic banking

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crises has been systematically investigated by many researchers, international financial institutions, and central banks with the purpose of prudential policymaking.

The empirical studies on the EWS for currency crises and systemic banking crises are numerous, especially after the 1997–1998 Asian financial crisis, where the majority of these studies apply two popular approaches, namely Logit/Probit and Signal (e.g. Berg & Pattillo, 1999; Demirgüç-Kunt & Detragiache, 1998; Edison, 2003; Falcetti & Tudela, 2008; Frankel & Saravelos, 2012; Kaminsky et al., 1998; Kaminsky & Reinhart, 1999). In recent years, a number of other approaches have also been developed and used in the EWS construction. Two models, the Bayesian Model Averaging (BMA) and the Two-Stage Least Squares (2SLS), stand out among others (e.g. Babecký et al., 2014; Crespo-Cuaresma & Slacik, 2009; Hosni, 2014). As to the case of Vietnam, Vo et al. (2016), Nguyen and Nguyen (2017), and Nguyen (2016) have examined the usefulness of EWS in predicting currency crises, through using either signal method or combinations of signal and Probit methods.

To the best of our knowledge, there has been no attempt to integrate and apply all of the four abovementioned approaches in an EWS framework for currency and systemic banking crises before. While each model has its own advantages, combining all of them might provide an EWS, which is stronger than each individual approach. We also go one step further by introducing specific variables that have not been considered in previous studies within the Vietnamese context such as the banking-sector fragility index, the dollarisation, and the global financial index. It is finally worth noting that this research issue would particularly be a priority for both academics and policymakers given Vietnam's amazingly increasing economic openness to global markets as well as potential vulnerability due to its macroeconomic instability.

As end of 2015, the Vietnamese commercial banking system consisted of 4 state-owned commercial banks, 31 joint-stock commercial banks, 5 foreign-owned banks, 30 joint-venture banks and 50 branches of foreign banks (State Bank of Viet Nam [SBV], 2016). The degree of banking openness of Vietnam, which measures the total cross-border banking activities divided by the total banking assets, still remains low compared to other countries in the region ASEAN and around the world (Ha et al., 2020). Yet, the banking system constitutes an important part of the Vietnamese economy with a total asset size to GDP of 118%.[1] Moreover, according to the General Statistics Office of Vietnam, the contribution of the Vietnamese banking sector to the country's economy has been rising dramatically in the aftermath of the GFC from 1.91% in 2009 to 5.49% in 2015. Therefore, the Vietnamese economy and domestic banking system require close monitoring.

Regarding the Vietnam's currency regime, it is classified as a stabilised arrangement within a state-regulated market (IMF, 2015) and the country does not follow inflation targeting as its main monetary policy, unlike many other emerging markets. In fact, according to Law on its central bank, Vietnam follows a multi-target monetary policy including, among others, currency value stability and the annual inflation rate target. According to the currency crisis models of Krugman (1979) and Flood and Garber (1984), the risk of a currency crisis in Vietnam cannot be ignored. In the case of a speculative currency attack, it is likely that the State Bank of Vietnam might find itself in a condition without enough foreign exchange reserves to intervene to the depreciation of the local currency. In such a case, if the speculative attack sustains long enough, the currency crisis might be transmitted to the local interbank market, thus threatening the stability of the

whole banking system and potentially causing a banking crisis. This scenario of simultaneous crises with a propagation risk through a feedback system (just as in the case of 1997–1998 Asian financial crisis) is a real threat to Vietnam since the country's financial liberalisation is entering a final stage of an entirely open capital flow system.

Worse, in legal terms, the country is not ready for such a crisis with potential consequences of bank defaults. The reason is that the Law on Credit Institutions has not yet officially recognised the terms of bankruptcy in banking sector even though the Law on Bankruptcy was passed in 2014. The explanation for this delay is that the banking sector is considered sensitive and cannot rely on events, such as M&A activities or grants from the State Bank of Vietnam to signal the banking crisis. The early warning systems for currency and systemic banking crises are thus essential and require a close attention for maintaining the exchange rate stability, stabilising the banking system, and achieving policy goals.

Overall, we aim to develop an EWS framework for currency and banking crisis by simultaneously four different approaches (Signal, Logit/Probit, 2SLS and BMA) in order to achieve the highest prediction efficiency. Since each approach has its own strengths and weaknesses, no method is perfect and superior to the other all the time. For example, the advantage of the signal approach is being a non-parametric approach allowing one to estimate the probability of a currency or systemic banking crises directly without a control sample, which is required for the Logit/Probit approach. It also has the advantage of allowing multiple warning indicators to be used at the same time, helping to keep track of comprehensive indicators, tracking each indicator, and helping assess the abnormal fluctuations of each indicator as well each aspect of the economy, which assess the risk of overall crisis. However, the disadvantage of the signal approach is that it ignores the interaction between variables, which may together convey crisis information. The reason is that in reality, not all variables can foretell crisis risk as well as provide the necessary warning signals, but the impact of a particular variable can be neutralised, excluded or motivated by the other. On the other hand, this limitation of the Signal approach is an advantage of the Logit/Probit model. Moreover, the BMA supports the verification of the robustness and relevance of the variables used through selecting the best possible variables in the context of uncertainty. It is interesting to note that the 2SLS technique is the best support for the other three approaches (Signal, Logit/Probit and BMA) because it can estimate the structural parameters of the equation system simultaneously to avoid the bias and inconsistency of the simultaneous equation, whereas the others only build an EWS based on a single equation without the possibility of taking into account the random, dynamic and simultaneous nature of the macroeconomic variables in the system. All in all, these reasons motivate the integration of the four approaches as they help evaluate, compare and verify the results of early warnings of currency and systemic banking crises, which brings robustness and helps making the EWS judgement more convincing.

Accordingly, we use the above-mentioned approaches to construct an EWS for understanding and predicting currency and systematic banking crises in Vietnam based on various macroeconomic and financial variables over the period from 2002 to 2016. The choice of this period for the in-sample (2002–2015) and out-of-sample (2016) analysis is particularly motivated by notable fluctuations and important instabilities of the Vietnamese banking system as a result of high non-performing loans and sluggish credit growth.[2] Our findings predict a low probability of a currency or banking crisis and also

reveals the important role of macroeconomic variables in designing early warning systems for such crises in Vietnam.

The rest of this paper is structured as follows: Section 2 presents the methodologies used in this paper. Section 3 reports empirical findings. Section 4 provides some discussions. Finally, Section 5 concludes with potential policy implications.

2. Empirical methods

2.1. Identifying currency crisis

A currency crisis occurs when the value of the local currency drops significantly in a short period of time and the depreciation forces the government to protect its domestic currency by raising interest rates or spending large amounts of foreign exchange reserves (Kaminsky et al., 1998).

One measure to track such situations is the Exchange Market Pressure (*EMP*) index introduced by Eichengreen et al. (1995, 1996) and it is often used to identify periods of currency crises. The *EMP* index, described in Equation (1), is a weighted average of changes in exchange rate (*NER*), foreign exchange reserves (*res*), and real interest rates (*r*). The exchange rate is said to be under 'stress' (with selling pressure) if there is a significant increase in the exchange market pressure index.

$$EMP_{i,t} = \omega_{NER}\left(\frac{NER_{i,t} - NER_{i,t-1}}{NER_{i,t-1}}\right) + \omega_r\left(r_{i,t} - r_{i,t-1}\right) - \omega_{res}\left(\frac{res_{i,t} - res}{res_{i,t-1}}\right) \quad (1)$$

where ω_i is the weighting for the corresponding change in the index *i* (*NER, r and res*) calculated as reverse value of the standard deviation of the relative change in the index *i*. The currency of a country will be under pressure to devalue if the *EMP* index exceeds 1.5 times the standard deviation from the in-sample mean.

In this study, the Vietnam's *EMP* index for the period from January 2002 to December 2016 is calculated based on the data provided by the International Monetary Fund's International Financial Statistics (IFS). According to the Probit/Logit model, the period of currency crises (CC) in Vietnam is recorded as follows:

$$CC_t = \begin{cases} 1 if EMP \geq \mu EMP + 1.5\sigma_{EMP} \\ 0 otherwise \end{cases} \quad (2)$$

2.2. Identifying systemic banking crisis

According to Laeven and Valencia (2012), a banking crisis is considered as 'systemic' if two conditions are met: (i) Significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and/or bank liquidity); (ii) Significant banking policy interventions in response to these significant losses in the banking system. Laeven and Valencia (2012) note that the first year in which both criteria are met is the year in which the crisis becomes systemic. It is important to consider policy interventions in the banking sector if at least three of the following six measures are used: (i) widespread liquidity support (5% of deposits and liabilities to non-residents); (ii) total bank restructuring costs (at least 3% of GDP); (iii) significant bank nationalisations; (iv)

significant guarantees are given; (v) significant asset purchases (at least 5% of GDP); and (vi) frozen deposits and/or bank holidays.

In order to determine the banking crisis periods in Vietnam, we use the Banking Sector Fragility (BSF) index, which was proposed by Kibritcioglu (2003) and is represented in Equation (3) as follows:

$$BSF3 = \frac{\left(\frac{CPS_t - \mu_{CPS}}{\sigma_{CPS}}\right) + \left(\frac{FL_t - \mu_{FL}}{\sigma_{FL}}\right) + \left(\frac{DEP_t - \mu_{DEP}}{\sigma_{DEP}}\right)}{3} \quad (3)$$

where *BSF3* is the mean of standard values for *CPS, FL*, and *DEP*. μ and σ are the arithmetic mean and standard deviation of these three variables, respectively. CPS, FL, and DEP refer to the corresponding 12-month percent changes in bank's statement about (or credit for) the domestic private sector, bank foreign liabilities and bank deposits. In this study, the Vietnamese national banking system falls into a medium- and high-vulnerability period, if the value of the *BSF3* is between 0 and – 0.5 and lower than – 0.5, respectively.

In addition, Kibritcioglu (2003) shortly defines an alternative indicator of banking sector fragility, *BSF2*, to test the idea that bank operations do not play an important role in modern banking crises. The *BSF2* is calculated by ignoring the role of changes in actual bank deposits for banks' financial vulnerability, and thus any deviation of *BSF2* from *BSF3* will help us to understand the relative importance of bank operations in banking crises.

Both the *BSF3* and *BSF2* indices for the Vietnamese banking system in the period from January 2002 to December 2016 are calculated based on the same IFS data source used in the EMP index, and the periods of banking crises (*BC*) in Vietnam are recorded in Probit/Logit model as follows:

$$BC = \begin{cases} 1 if there is a systemic banking crisis \\ 0 otherwise \end{cases} \quad (4)$$

2.3. Early warning indicators of currency and systemic banking crises

The selected early warning indicators for Vietnam are based on the following three items: i) a review of various studies (e.g. Ari, 2012; Babecký et al., 2014; Berg & Pattillo, 1999; Demirgüç-Kunt & Detragiache, 1998; Edison, 2003; Hosni, 2014; Kaminsky et al., 1998; Kaminsky & Reinhart, 1999; Kibritcioglu, 2003); ii) their applicability to Vietnam; and iii) the availability of the data. In order to ensure the reliability and accuracy of the dataset, the study uses a combination of various sources such as IFS, CEIC, Bloomberg LP, Datastream, World Development Indicators (WDI), and ADB – Key Indicators for Asia and the Pacific (see Table 1). In addition, the data is adjusted for seasonality where available.

2.4. Early warning approaches for currency crises and systemic banking crises

In order to set up an EWS for currency and banking crises, we follow a three-stage procedure. First, we identify the periods of currency crises (with EMP) and systemic banking crises (with BSF) in Vietnam. Second, we construct early warning indicators for

Table 1. The potential early warning indicators for currency crises and systemic banking crises.

Indicator	Symbol	Currency crises	Banking crises	Expected Sign	Source	Variables' description	Used in other studies
Real exchange rate	REER	x	x	-	Authors' calculation	12-month percent changes in the real effective exchange rate. Vietnam's real effective rate is calculated by the using a basket of currencies comprising 10 major trading partners with Vietnam (China, USA, Japan, Europe, South Korea, Singapore, Thailand, Malaysia, Australia and India)	
Exports	EX	x	x	-	IFS	12-month percent changes in exports	Kaminsky et al. (1998); Kaminsky and Reinhart (1999); Berg and Pattillo (1999); Edison (2003); Ari (2012); Demirgüç-Kunt and Detragiache (1998); Davis & Karim (2008).
Imports	IM	x	x	+	IFS	12-month percent changes in imports	Kaminsky et al. (1998); Kaminsky and Reinhart (1999).
M2/reserves	M2RES	x	x	+	IFS	M2 converted into dollars, divided by foreign exchange reserves (gold excluded).	Kaminsky et al. (1998); Kaminsky and Reinhart (1999); Berg and Pattillo (1999); Edison (2003); Demirgüç-Kunt and Detragiache (1998); Davis & Karim (2008).

(*Continued*)

Table 1. (Continued).

Indicator	Symbol	Currency crises	Banking crises	Expected Sign	Source	Variables' description	Used in other studies
Reserves	RES	x	x	-	IFS	12-month percent changes in foreign exchange reserves (gold excluded).	Kaminsky et al. (1998); Kaminsky and Reinhart (1999); Edison (2003); Berg and Pattillo (1999)
M2 multiplier	M2	x	x	+	IFS	12-month percent changes in ratio of M2 to base money.	Kaminsky et al. (1998); Kaminsky and Reinhart (1999), Edison (2003).
Domestic credit/GDP	DCGDP	x	x	+	IFS, Datastream	12-month percent changes in ratio of M2 to real GDP. Monthly real GDP was interpolated from annual data.	Kaminsky et al. (1998), Kaminsky and Reinhart (1999), Edison (2003), Ari (2012).
Real interest rates	RIR	x	x	+	IFS	Deposit rate deflated using consumer prices. Monthly rates expressed in percentage points.	Kaminsky et al. (1998), Kaminsky and Reinhart (1999), Edison (2003), Ari (2012).
Lending-deposit rate ratio	LDRR	x		+	IFS	Lending rate to deposit rate	Kaminsky et al. (1998), Kaminsky and Reinhart (1999), Edison (2003).
Bank deposits	DEP	x	x	-	IFS	12-month percent changes in bank deposits.	Kaminsky et al. (1998), Kaminsky and Reinhart (1999), Edison (2003).
Banking sector fragility index	BSF	x			Authors' calculation		Available in Kibritcioglu (2003)
Not used up to now							
Real interest rate differential	RIRD	x	x	+	IFS	Real interest rates in Vietnam minus real interest rates in the United States.	Kaminsky et al. (1998), Kaminsky and Reinhart (1999), Edison (2003).
Industrial production	OUTPUT	x	x	-	CEIC	12-month percent changes in industrial production.	Kaminsky et al. (1998), Kaminsky and Reinhart (1999), Edison (2003).

(*Continued*)

Table 1. (Continued).

Indicator	Symbol	Currency crises	Banking crises	Expected Sign	Source	Variables' description	Used in other studies
Stock composite index	SRI	x	x	-	Bloomberg LP	12-month percent changes in stock composite index.	Kaminsky et al. (1998); Kaminsky and Reinhart (1999); Edison (2003).
Dollarisation	FCDM2	x		+	IFS	12-month percent changes in foreign currency deposit to M2.	Not used up to now
The impact of the global financial crisis	RFC	x	x	+		RFC = 1 during the global financial crisis of 2008 (from August 2007 to March 2009) and RFC = 0 if there is no crisis.	Not used up to now
Loans/banks deposit	CD		x	+	IFS	12-month percent changes in loans to banks deposits.	Demirgüç-Kunt and Detragiache (1998);
Exchange market pressure index	EMP		x	+	IFS	Available in Rose & Wysplosz (1995, 1996).	Yiu, Ho, & Jin (2009).
Inflation	INF		x	+	IFS	12-month percent changes in consumer price index.	Demirgüç-Kunt and Detragiache (1998); Davis & Karim (2008); Yiu, Ho, & Jin (2009).

currency and systemic banking crises by combining the four approaches discussed below. Third, we calculate the probabilities of currency and systemic banking crises.

2.4.1. Signal approach

The Signal approach was introduced by Kaminsky et al. (1998). This approach monitors the volatility of macroeconomic indicators to detect abnormal changes in these indices and calculates their impact on the probability of a crisis. When these indicators exceed the allowable threshold, they immediately signal a crisis alert. The probability of a crisis is the weighted average of the crisis signals generated by the set of macroeconomic indicators.

For our case, warnings for currency crises and systemic banking crises were implemented by the Signal model using a 24-month rolling window. The corresponding steps define the threshold values and noise-to-signal ratios of early warning indicators for currency or systemic banking crises as well as monitor the volatility of the corresponding early warning indicators. If any indicator exceeds the threshold value, it is likely that the crisis will occur in the country under consideration within the next 24 months.

2.4.2. Logit/Probit model

Probit and logit were proposed by Goldberger (1964) and Maddala (1983) respectively. In addition, Wooldridge (2015) showed that regression results from the Logit and Probit models were similar, except for normal distribution. In this step, the currency crisis variable (CC_t) or the banking crisis variable (BC_t) is transformed into the forward-looking crisis variable Y_t which is defined as follows:

$$Y_t = \begin{cases} 1 if t = 1, 2, 3 \ldots, 24 s.t. CC_t or BC_t = 1 \\ 0 otherwise \end{cases} \tag{5}$$

As for the explanatory variables, we select 16 potential early warning indicators for currency crisis and 15 potential early warning indicators for systemic banking crises (Table 1).

2.4.3. Bayesian model averaging

Bayesian Model Averaging (BMA) calculates the mean values of the parameters of all alternative models. This approach uses a simple Monte Carlo simulation model (MC3) to evaluate the posterior distribution based on the work of Madigan and York (1995), Fernandez et al. (2001). As such, BMA can detect the determinants of currency and systemic banking crises in a context of uncertainty (Babecký et al., 2014).

Accordingly, the robustness of a variable in explaining the dependent variable can be expressed by the posterior inclusion probability (PIP) as follows:

$$PIP = p\left(\beta_y \neq 0 | y\right) = \sum_{\beta_y \neq 0} p\left(\{M_y | y\}\right) \tag{6}$$

A variable with a high PIP (>0.5) can be considered as the strongest early warning indicator. Warning for currency crises and systemic banking crises are carried out by BMA with independent variables and dependent variables identified similarly to the Probit model mentioned above.

2.4.4. Two stage least squares

The Two-Stage Least Squares (2SLS) estimator has been widely used to estimate the coefficients of a system of simultaneous equations. It was introduced more or less independently by Theil (1953a, 1953b, 1954, 1961), Basmann (1957), and Sargan (1958). The 2SLS estimation process consists of two steps; i) estimating reduced forms for each endogenous variable as a function of all exogenous and predetermined variables by Ordinary Least Squares regression (OLS), then ii) calculating the set of fitted values of the endogenous variables implied by the reduced forms. Then, these fitted values are applied as independent variables in the structural equations. In order to implement the warning of currency and systemic banking crises in Vietnam under 2SLS method, we set up the simultaneous system of Equations (7) and (8) as follows:

$$Y_t^{B^*} = \gamma_B Y_t^{C^*} + \beta_B X_t^B + \varepsilon_t^B \tag{7}$$

$$Y_t^{C^*} = \gamma_C Y_t^{B^*} + \beta_C X_t^C + \varepsilon_t^C \tag{8}$$

where $Y_{it}^{B^*}$ and $Y_{it}^{C^*}$ are endogenous variables representing, respectively, the systemic banking crisis (BSF index) and the currency crisis (EMP index). γ_B and γ_C respectively are parameters that reflect the causal relation between systemic banking crisis and currency crisis. X_{it}^B and X_{it}^C are exogenous variables, which warn the systemic banking crisis and currency crisis, respectively.

3. Empirical results

3.1. Period of currency crises

Figure 1 shows the evolution of the Vietnamese EMP index. There are eight phases identified as risk of currency crises in Vietnam (EMP > 2.9) occurring in the period between 2008 and 2011, corresponding to high macroeconomic instability in the country. However, currency crises in Vietnam are short lived, lasting from 1 to 3 months. In

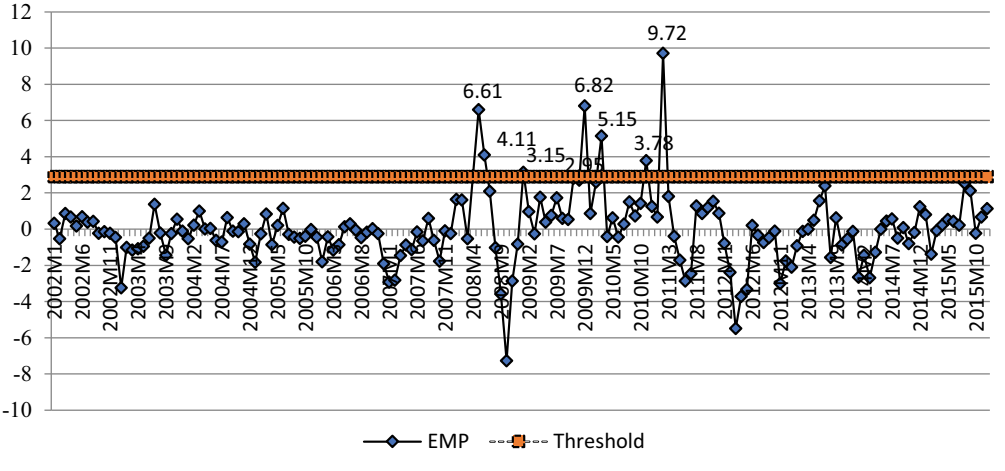

Figure 1. Vietnam EMP index, 2002–2015.

addition, these currency crises only affect the domestic economy, not spread to other countries as it occurred in Mexico in the period 1994–1995 or other Asian countries in the period 1997–1998.

A particular aspect associated with currency crisis is that the speculative monetary attacks in Vietnam also occur on a small scale in the country, without the involvement of international hedge funds. Although there is no document or statistical record of currency crises in Vietnam so far, the most obvious manifestation is the intervention of the State Bank of Vietnam at the time before or immediately when the currency crisis occurred in order to response the currency speculative attacks, to protect the domestic currency through measures, such as raising interest or selling foreign exchange reserves. This has been described in studies by Eichengreen et al. (1996), and Glick and Hutchison (2011). The State Bank was clearly aware that with low foreign exchange reserves, it is difficult to be able to withstand any speculative attacks. Therefore, in addition to the above-mentioned two measures, in order to cope with speculative attacks, the State Bank also uses other measures such as direct intervention in exchange rates, compulsory reserves and administrative measures. After a series of interventions during 2008–2011, the State Bank successfully defended the local currency against speculation.

3.2. Period of systemic banking crises

In Figure 2, the volatility of Vietnamese BSF index for the period 2002–2015 is presented and it reflects the medium- and high-fragility periods in Vietnamese banking system.

According to *BFS2 and BSF3*, the systemic banking crises occurred from January 2009 to May 2009 and from May 2011 to December 2015 (see Table 2). However, although Vietnamese banking system is still experiencing medium-fragility periods, it is gradually recovering since mid-2015, with both *BSF* measures hovering around zero.

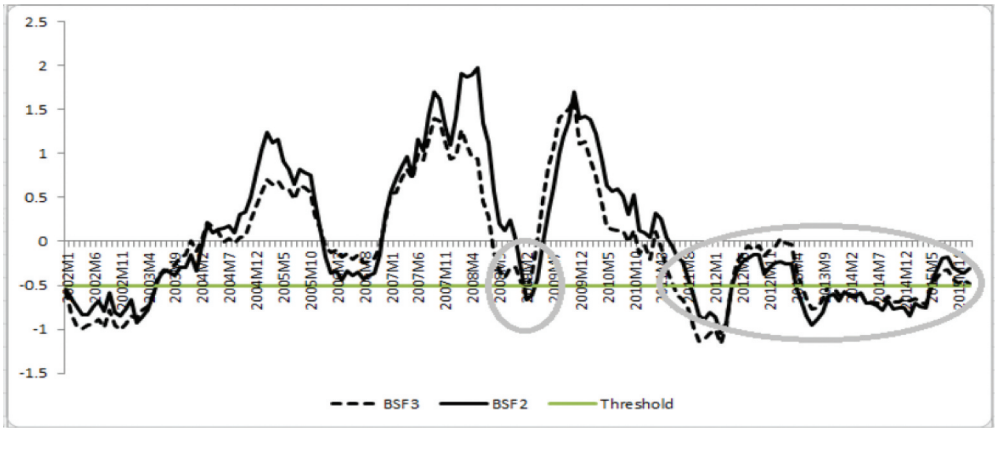

Figure 2. Vietnam BSF index, 2002–2015.

Table 2. Medium- and high-fragility periods in the Vietnamese banking system.

BSF3		BSF2	
Medium	High	Medium	High
– – – -	January 2002-May 2003	– – – -	January 2002-May 2003
June 2003-November 2003	– – -	June 2003-February 2004	– – –
January 2006 -November 2006	– – -	January 2006-November 2006	– – –
August 2008-March 2009	– – -	January 2009	February 2009-March 2009
– – –	– –	April 2009-May 2009	– – -
November 2010-May 2011	June 2011-April 2012	May 2011-August 2011	September 2011-April 2012
May 2012-April 2013	May 2013-May 2015	May 2012-March 2013	April 2013-April 2015
June 2015-December 2015	– – –	May 2015-December 2015	– – –

3.3. Indicators for currency and systemic banking crises

Table 3 presents the results of the estimation of the Signal, Logit and BMA models for the period from January 2002 to December 2015. In the case of currency crisis, the Signal model shows that six variables have high warning effects including EX, M2RES, RES, M2, SRI and REER. On the other hand, Logit model indicates that 11 variables (stock composite index, real effective exchange rate, exports, M2/reserves, bank deposits, reserves, M2 multiplier, the impact of the GFC, the banking sector fragility index (*BSF*), real interest rate differential and the existence of dollarisation in the economy) have statistically significant coefficients and have the same sign as expected in theory, therefore provides consistency to the empirics-theory relationship. In addition, the BMA results show that the banking crisis is characterised by 10 variables with PIP > 0.5 including RIRD, SRI, BSF, EX, RES, REER, FCDM2, DEP, M2, RFC, especially DCGDP and SRI are the two strongest indicators for currency crisis in Vietnam with PIP = 1. Thus, aggregate results from three models (Signal, Logit and BMA) have identified the 11 variables proposed in warning model for currency crisis.

When similar analysis is performed for the case of the systemic banking crisis, 15 indicators are addressed, and they are presented in Table 3. The above results are in line with those of Kaminsky et al. (1998), Demirgüç-Kunt and Detragiache (1998), and Kaminsky and Reinhart (1999), Glick & Hutchinson (1999), Berg and Pattillo (1999), Edison (2003), Davis & Karim (2008), Davis & Karim (2008), Ari (2012), and Babecký et al. (2014).

Thus, there are eight variables which are both good warning indicators of the currency crisis as well as the systemic banking crisis. During the study period, the fluctuation of these variables was closely linked to the periods of currency and systemic banking crises.

3.3.1. M2/Reserve

In the period between 2008 and 2011, M2/reserves suddenly increased and reached its highest levels. The direct cause is the sharp drop in foreign exchange reserves to negative levels in the losses from 2008 to 2011 when the short-term currency crisis occurred in Vietnam, while the growth of M2 remained positive, it declined from 40% (June 2009) to less than 20% (December 2011) (Figure 3). The reserves sharply dropped from USD 23.5 billion in 2007 to USD 13.5 billion in 2011. However, during the years between 2012 and 2014, it began to rise again and reached USD 34.2 billion in 2014 and as of the end of 2015, it is around USD 28.3 billion.

According to international practice, having foreign reserves to cover the total amount of foreign debt to be repaid within a year and the three months of imports is enough to

Table 3. Warning for currency crises and systemic banking crises results.

	Probit (Coefficient)		BMA (PIP)		Signal (Number of signals)		2SLS (Coefficient)	
Variable	Currency crises	Systemic banking crises	Currency crises	Systemic banking crises	Currency crises	Systemic banking crises	Currency crises	Systemic banking crises
RIRD	1.2944***		1.0000				0.0033***	
	(0.3760)						(0.0009)	
SRI	−0.0762***	−0.0104**	1.0000		49[e]	51[e]		
	(0.0218)	(0.0044)						
BSF	−3.5661***		0.9998				−0.1777***	
	(1.0036)						(0.0817)	
EX	−0.0629***	−0.0439**	0.9996	0.7239	10[e]	10[e]	−0.0077***	−0.0085**
	(0.0238)	(0.0175)					(0.0025)	(0.0053)
RES	−0.0819**		0.9931		28[e]	7[e]	−0.0053**	
	(0.0342)						(0.0018)	
REER	−0.7807***	−0.3403**	0.9747	0.9707	7[e]	7[e]	−0.0357***	−0.0046**
	(0.2244)	(0.1352)					(0.0192)	(0.0026)
FCDM2	0.1722**		0.9511				0.0171***	
	(0.0680)						(0.0062)	
DEP	−0.2982**	−0.3263**	0.5603				−0.0277**	
	(0.1411)	(0.1337)					(0.0101)	
M2	0.0806*		0.5445		39[e]	49[e]		
	(0.0457)							
RFC	2.6180*	1.5190**	0.5031	0.9764			0.0667***	0.0187***
	(1.4335)	(0.6862)					(0.0147)	(0.0083)
M2RES	0.0424**				51[e]	58[e]		
	(0.0195)							
DCGDP		0.2734***		1.0000		117[e]		0.8903***
		(0.0599)						(0.1612)
INF		0.6539***		1.0000				0.0037***
		(0.1437)						(0.0011)
RIR		0.4033***		0.9994				0.0892**
		(0.1436)						(0.0494)
EMP		0.2478**		0.5811				0.2088**
		(0.1163)						(0.0965)
OUTPUT		−0.0453*		0.5062				
		(0.0419)						
IM						78[e]		

(*Continued*)

Table 3. (Continued).

	Probit (Coefficient)		BMA (PIP)		Signal (Number of signals)		2SLS (Coefficient)	
Variable	Currency crises	Systemic banking crises	Currency crises	Systemic banking crises	Currency crises	Systemic banking crises	Currency crises	Systemic banking crises
CD		0.2012* (0.1184)						0.0959** (0.0460)
Result	McFadden R-squared = 0.7965	McFadden R-squared = 0.7307	Cumulative Model Prob. = 0.86	Cumulative Model Prob. = 0.67	NA	NA	R-squared = 0.6045	R-squared = 0.5992

Notes: ***, **, and * denotes significance at 1%, 5%, and 10% respectively. [e] denotes a good signal or a highly effective early warning indicator of the potential systemic banking crisis or currency crisis. See Table 1 for the definition of the variables used.

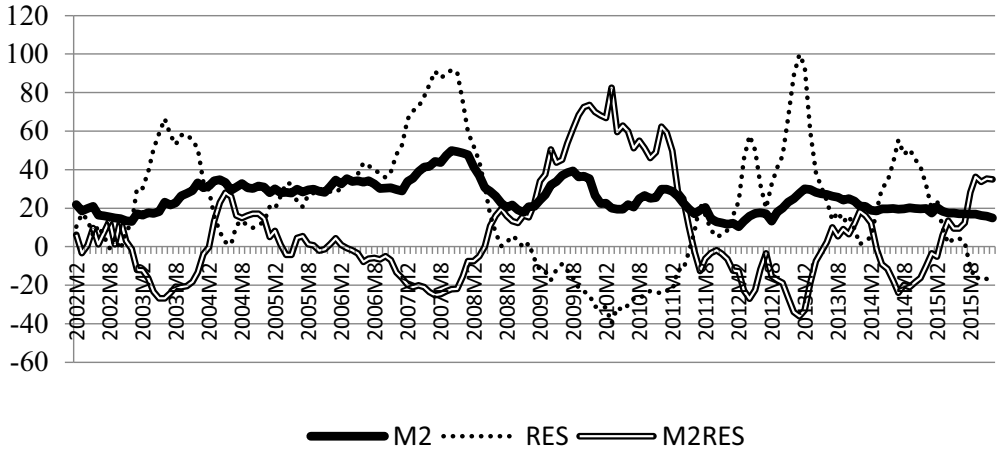

Figure 3. Growth of money supply (M2), M2/reserves (M2RES), and foreign exchange reserves (RES), 2002–2015.

prevent a currency crisis. However, Vietnam's foreign exchange reserve is 50% lower than the short-term total foreign debt, and worse, it is equivalent to only 1.9 months of imports by 2015, lower than the lowest fixed limit of 1.1 months. The lack of foreign exchange reserves is a worrying sign of the risk of a currency attack, especially considering the fact that country is increasingly relying on imports in the last years.

3.3.2. Real exchange rate

Figure 4 shows that Vietnam's real effective exchange rate growth started falling sharply in March 2007 and dropped to its lowest level in October 2008, suggesting an overvalued exchange rate. Consequently, the State Bank of Vietnam had to respond and accordingly adjust the exchange rate strongly in December 2009 and February 2011.

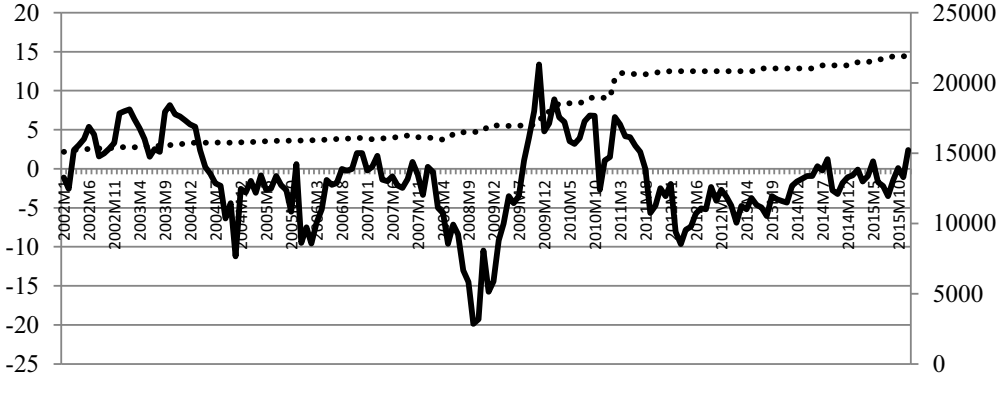

Figure 4. Real effective exchange rate growth (solid line) and exchange rate (dotted line) in Vietnam, 2002–2015.

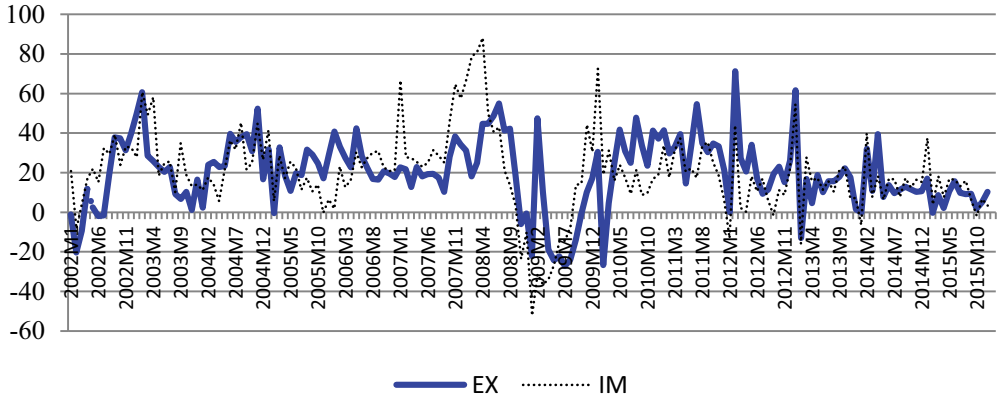

Figure 5. Performance of Vietnam's export (EX) and import (IM) growth, 2002–2015.

3.3.3. Performance of export and import growth

Figure 5 shows that both growth values reached to negative levels in the period from May 2008 to April 2010, which is a warning indicator of a potential currency crisis in Vietnam. Indeed, the country really experienced currency crises in the period from 2008 to 2011, similarly a systemic banking crisis during the periods from January 2009 to May 2009 and from May 2011 to December 2015. Prior to these stages, Vietnam's import growth had begun to increase rapidly from January 2006 to peak in June 2008. Especially, import growth continued to increase strongly on the timing of systemic banking crises in the country.

3.3.4. Financial market variables

The 2008–2009 GFC is found to have a strong impact on the probability of observing currency and systemic banking crises in Vietnam. These results are supported by the theoretical views of Fratzscher (2003), and Glick and Rose (1999). In fact, following the onset of the GFC, short-term currency crises occurred in Vietnam in the period between 2008 and 2011 and the systemic banking crisis shows that the FCDM2 (Dollarisation) growth accelerated after falling to its lowest level in July 2007 and peaked in July 2008.

Figure 6 shows that the stock composite index rose sharply and peaked in the early months of 2007 right after Vietnam's accession to the World Trade Organization (WTO), coupled with an expansionary monetary policy and high credit boom. Then, the GFC occurred, and the stock indexes have fallen rapidly since the late months of 2007. In particular, the stock composite index fell to below 50% from November 2007 to May 2009. Thus, the collapse of the stock composite index signalled currency crises and systemic banking crises in Vietnam.

In the context of the short-term currency crises from 2008 to 2011 and during systemic banking crises in the country, bank deposits have decreased significantly compared to the previous periods. The decline in bank deposits in the banking system caused liquidity shortage and financial instability and put a heavy pressure on the foreign exchange market. The loans/banks deposit ratio has always been more than 1 since 2002, indicating that Vietnamese banking system has been constantly facing liquidity risk (e.g. Agribank, HDB, OCB, Kien Long, SGB, BID, CTG, EIB). Besides, Vietnam's loans/banks deposit ratio

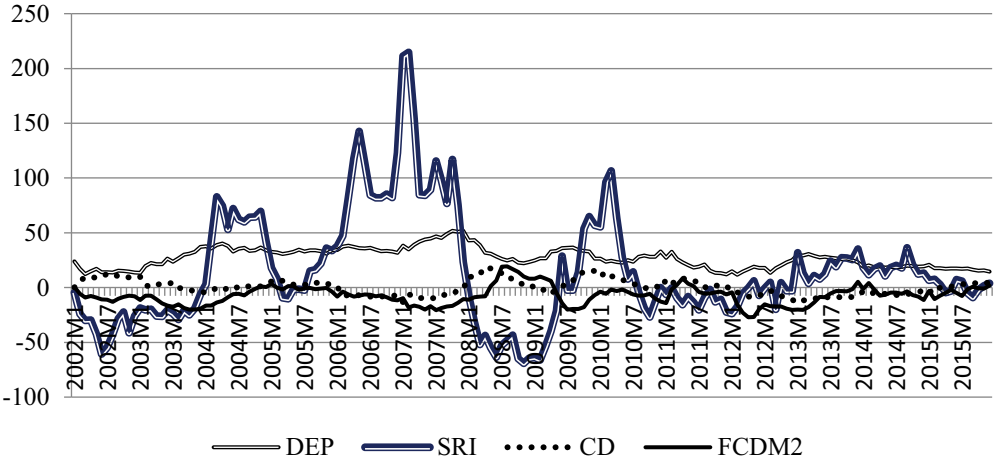

Figure 6. 12-month percentage changes in bank deposits, loans/banks deposit, stock composite index and dollarisation, 2002–2015.

increased in the period from August 2008 to April 2008, then declined and started to increase again between May 2009 to January 2011. Not surprisingly, this is the period before the two systemic banking crises identified in Vietnam.

3.3.5. Real interest rates and real interest rates differential

Figure 7 shows that the real interest rates dropped to negative levels in the period from June 2007 to November 2008, then began to increase again in December 2008. In the first phase of the Vietnamese systemic banking crisis, the real interest rate increased sharply after the previous recession and in mid-2011. After the decline in the period from March 2011 to August 2011, the real interest rates have started to surge in the second phase of systemic banking crisis. Moreover, the real interest rate differential began to decline sharply from June 2007 to August 2008, leading to the withdrawal of foreign capital.

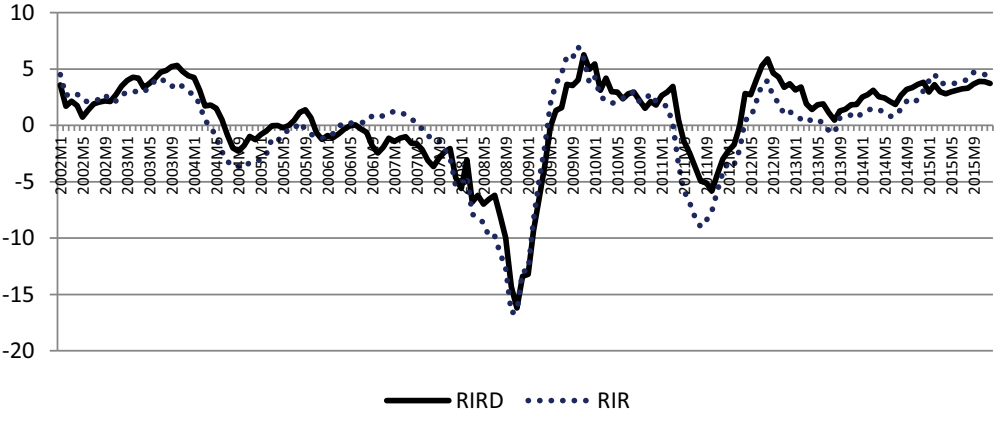

Figure 7. Vietnam's the real interest rates (RIR) and real interest differential (RIRD), 2002–2015.

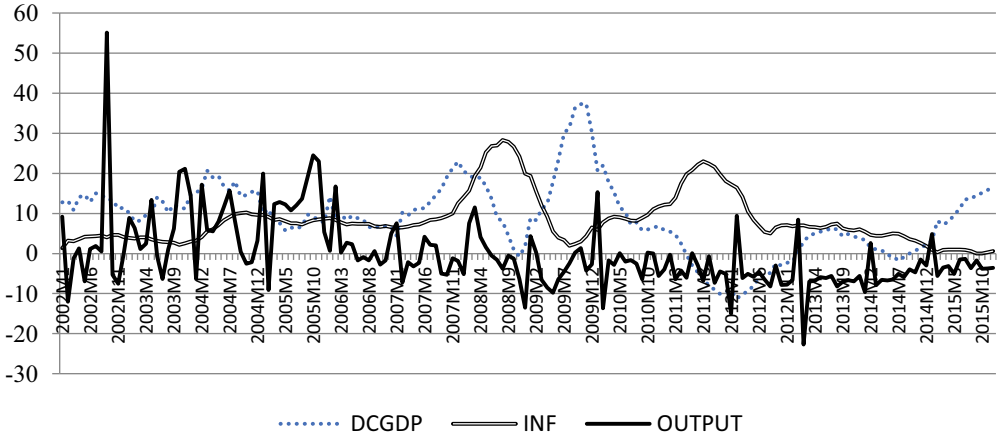

Figure 8. Performance of Vietnam's domestic credit/GDP (DCGDP), inflation (INF), and industrial growth (OUTPUT), 2002–2015.

From May 2008 to September 2008, the SBV tightened its monetary policy, the key interest rates were adjusted upward, in which the basic interest rate has increased from 12% to 14% per annum. As a result, the real interest rate differential has started to increase sharply since October 2008 and peaked in December 2009. The rise of the real interest rate differential signalled the devaluation risk of the domestic currency and the real short-term currency crises in Vietnam in 2008–2011.

3.3.6. Domestic credit/GDP, inflation, industrial production

Vietnam's domestic credit/GDP growth has been increasing steadily since January 2007. Specifically, domestic credit/GDP growth peaked first at 21%–23% in the period from November 2007-February 2008 and peaked again with 37% from September 2009 to November 2009, signalling the risk of systemic banking crisis in Vietnam. Given the domestic credit/GDP growth in the country, bad credit quality is responsible for a larger amount of NPLs in Vietnamese banking system, which in turn led to systemic banking crises (Figure 8).

Long-term high inflation had a negative impact on the business performance, affecting the quality of bank credit, resulting in high NPLs and financial instability in the banking system. Vietnam's monthly inflation during the systemic banking crises was over 25% from May 2008 to November 2008 and over 15% from April 2011 to February 2012. Accordingly, the country experienced a systemic banking crisis.

Vietnam's industrial production has also slowed down over the time since October 2005 and has fallen sharply during systemic banking crises periods. Declining industrial production adversely affects the financial situation of the business sector, leading to credit risks and NPLs in the banking system.

3.4. Predictions of currency and systemic banking crises

The EWS for predicting currency and systemic banking crises in Vietnam is achieved by combining the Signal and Logit models with a 24-month warning window from

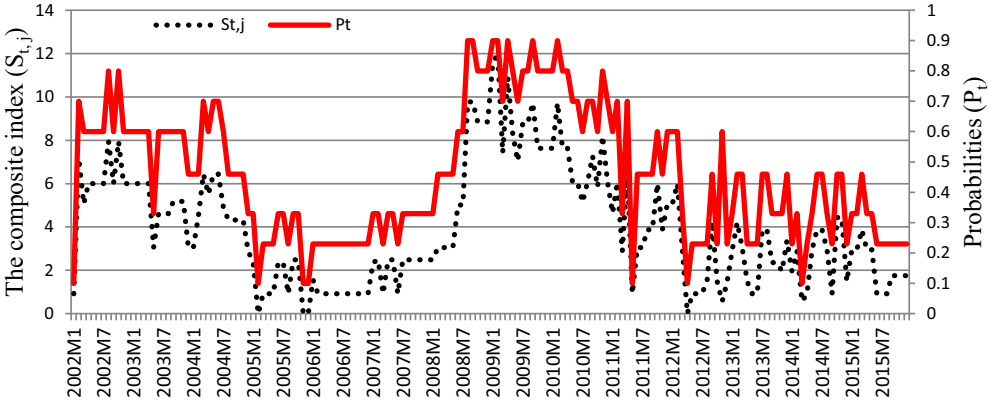

Figure 9. The composite index and probability of currency crises during 2002–2015.

January 2002 to December 2015 as reflected in Figures 9 and 10. In views of the discussions in Section 3.3, the warning systems were able to provide relatively accurate probability of crisis warning during the sample period. The probability of crisis occurrence is the highest between August 2008 and February 2010. Some vulnerabilities have been found in the last two quarters of 2002 and the second quarter of 2004, but they only appeared to be temporary.

When we extended the prediction to the out-of-sample period from January 2016 to December 2016 using the same methods, the results displayed in Figures 11 and 12 show that the estimated probabilities of currency and banking crises are quite low and range from 0.1 to 0.4. The crisis risk is thus expected to be small for the subsequent period given the improved macroeconomic stability and more matured financial institutions. In reality, Vietnam has attained a relatively high economic growth rate which is estimated at 6.5% on average over the period 2016–2020. Despite the harmful effects of the Covid-19 health crisis, the country finished the 2020 year with a growth rate of 2.9% and a record total trade amount of U$544 billions, compared to only US$328 billions in 2015.

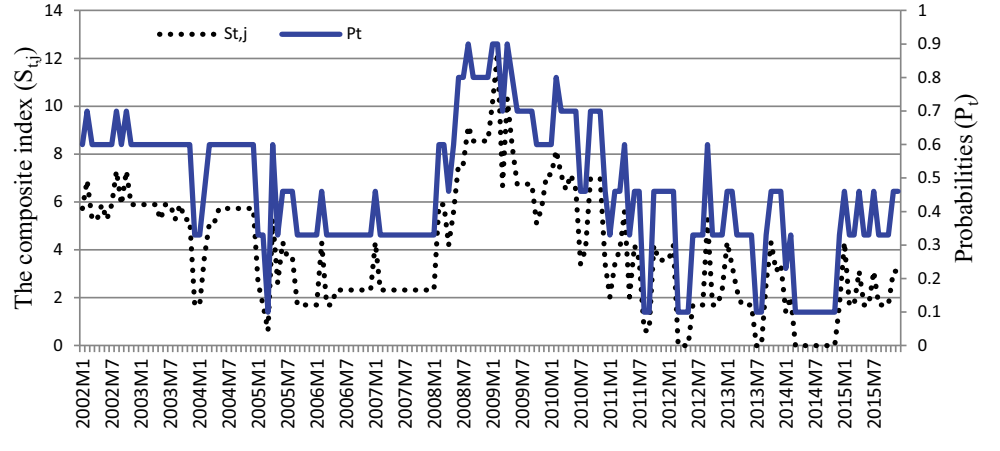

Figure 10. The composite index and probability of systemic banking crises during 2002–2015.

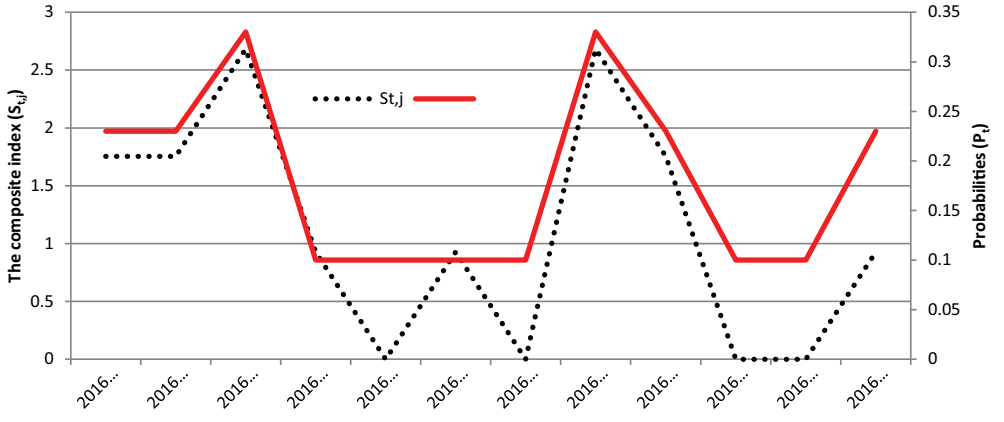

Figure 11. The composite index and out-of-sample probability of currency crises for 2016.

4. Discussions

4.1. Official versus unofficial crisis periods

We show, in Section 3, evidence of short-lived currency crises during the 2008–2011 period and systemic banking crises during the January 2009 to May 2009 period and the May 2011 to December 2015 period. One interesting question emerges as to whether these periods are considered as crisis periods by the authorities and to which responses the latter have adopted in order to stabilise the domestic banking system.

We start with the case of turbulent periods in the foreign exchange markets where we found a small-scale currency crisis in 2008–2011 through calculating the exchange market pressure index as in Eichengreen et al. (1995, 1996). While no public announcement has been made regarding a currency crisis, the dramatic exchange rate fluctuations and various interventions of the SBV during this period clearly proved this appearance. Intervening directly on exchange rates, raising interest rates and selling foreign exchange reserves are common measures that a central bank often uses to combat currency speculative attacks, to protect domestic currency value within a currency crisis

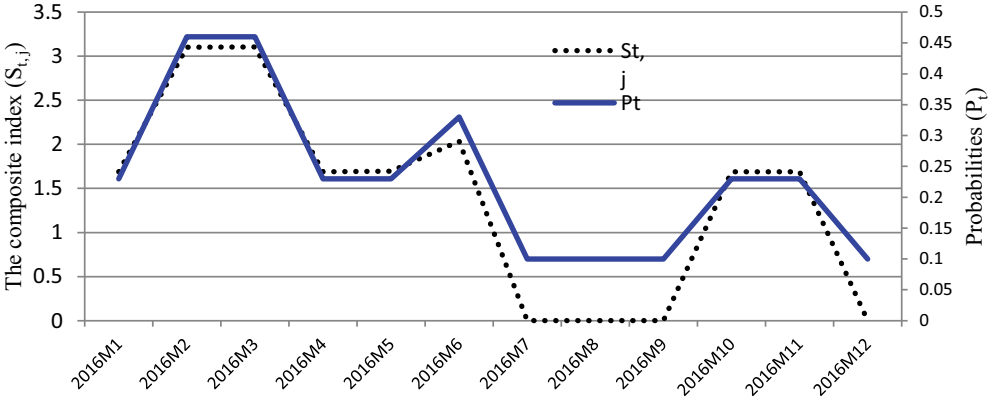

Figure 12. The composite index and out-of-sample probability of systemic banking crises for 2016.

(Eichengreen et al., 1996; Glick & Hutchison, 2011). More precisely, the USD/VND exchange rate experienced a highly turbulent period from 2008 to 2011. The SBV adjusted the USD/VND exchange rate fluctuation band 6 times in March 2008 (± 1%), June 2008 (± 2%), November 2008 (± 3%), March/2009 (± 5%), November 2009 (± 3%), August 2010 (2.1%), and February 2010 (3.3%), and officially devaluated VND in February 2011 (9.3%). The SBV also continuously sold foreign reserves to support liquidity for commercial banks, which made Vietnam's foreign exchange reserves sharply decline from 4.1 in 2007 to 3.2 in 2008 and only 1.4 months of imports (equivalent to $13.5 billion) in 2011. At the same time, the SBV has gradually increased interest rates between 2007 and 2011 from 6.5% to 15%.

With regards to systemic banking crises, one of the most important signals of such a situation was the surprise attack of depositors to withdraw their deposits. Note, however, that Vietnam's banking system has never faced such sensitive phenomena such as fleeing or bankruptcy because of implicit and explicit guarantees by the government. Until 15 January 2018, the Vietnam Law on Credit Institutions officially allowed bank bankruptcy. The SBV acquired three poor-performing commercial banks (Ocean Bank, GP Bank, and Vietnam Construction Bank) at zero VND in 2015, all of which now still operate under the SBV supervision.

Due to the shortcomings in the banking system, Vietnam has carried out Decision No. 254/Qd-Ttg dated 1 March 2012 approving the project on 'restructuring the system of credit institutions during 2011–2015' and Decision No. 1058/Qd-Ttg dated 19 July, 2017 on approving scheme for 'restructuring system of credit institutions associated with settlement of bad debts in the period of 2016–2020'.

Moreover, the high credit growth over a long period of time and the poor credit quality are the main causes of non-performing loans (NPLs) in the Vietnamese banking system, which have continuously increased from 2009 to 2015 and at an alarming rate of 4.9% in 2012. According to Fitch Ratings (2013), the actual number could, however, be three to four times higher than that and above 10% during the periods of January 2009–May 2009 and May 2011–December 2015 (Table 4). Therefore, consistent with the view of Demirgüç-Kunt and Detragiache (1998), the abovementioned 10% NPLs shows that the Vietnamese banking system has been in crisis during the mentioned period.

4.2. Depreciation versus appreciation in the context of currency crisis

In some specific cases, one might argue that depending on the country's being a net importer or exporter, a severe depreciation of the local currency (which is defined as a currency crisis) might not be too bad. In this section, we look at the currency crisis problem from this perspective for the case of Vietnam. Vietnam is a net importer till 2011,

Table 4. Vietnam's non-performing loans and credit growth rate during 2009–2015.

Indicators	2009	2010	2011	2012	2013	2014	2015
Non-performing loans (SBV, 2016) (%)	3.5	2.51	3.3	4.9	3.8	3.3	2.6
Non-performing loans*	12.5	8.5	13.3	17.2	13.3	11.6	10.5
Credit growth rate (%)	45.62	31.86	13.85	21.53	4.16	15.57	17.00

Source: World Bank (2019), *SBV and* Fitch Ratings (2013). *Non-performing loans were calculated by the authors using data from* Fitch Ratings (2013). *Due to lack of transparency, different accounting standards and debt classification, NPLs in Vietnam appeared to be four times higher than officially announced.*

Table 5. Vietnam's trade balance during 2002–2015.

Year	Export (USD billion)	Import (USD billion)	Trade balance (USD billion)
2002	16.704	19.734	−3.03
2003	20.142	25.194	−5.052
2004	25.984	31.47	−5.486
2005	31.726	36.408	−4.682
2006	39.605	44.409	−4.804
2007	48.313	60.697	−12.384
2008	62.685	80.714	−18.028
2009	57.096	69.948	−12.852
2010	71.658	83.779	−12.121
2011	94.518	104	−9.482
2012	115	115	0
2013	132	131	1
2014	150	149	1
2015	162.11	165.65	−3.54

Source: IMF (2019)

Table 6. Vietnam's external debt during 2002–2015.

Year	2002	2003	2004	2005	2006	2007	2008
External debt/GNI (%)	35,70	37,92	37,04	33,65	28,71	30,95	27,54
Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
External debt/GNI (%)	32,61	40,28	40,92	39,53	39,93	40,64	31,1

Source: World Bank (2019)

and the country got a trade surplus for the first time in 2012. However, the export surplus value is not high (see Table 5).

Additionally, the trade surplus is also unsustainable. Trade deficit was likely to return at any time. In 2015, Vietnam's trade balance was in deficit to 3.54 billion USD after 3 years of surplus. This lack of sustainability arises from Vietnam's reliance on imports of external raw and semi-processed materials. Therefore, the devaluation of the domestic currency does not help in the case of Vietnam in general, but it can lead to foreign debt burdens in the context of high external debt (see Table 6).

While the severe depreciation puts the country in a highly vulnerable position, an important appreciation of the local currency does not bring a positive scenario neither since it would reduce the export competitiveness and weaken the country's external position. Therefore, even the currency crisis is defined only for one direction (local currency depreciation) in the literature, it might also be a bad situation for Vietnam to have a significant appreciation of its currency in short notice. In other words, the key target would be the stability of currency for the stability of the Vietnamese economy.

5. Conclusion

This study develops early warning systems for currency and banking crises in Vietnam by combining four technical approaches. We find that Vietnam experienced short-lived currency crises during the 2008–2011 period, and similarly systemic banking crises in the periods from January 2009 to May 2009 and from May 2011 to December 2015. Our methods identify 11 macroeconomic variables having important effects on the early warning indicators of the currency crisis and another 15 macroeconomic variables in the case of

systemic banking crisis in the same period. Accordingly, eight macroeconomic variables (stock composite indexes, real effective exchange rates, exports, M2/reserves, bank deposits, reserves, M2 multipliers and the impact of the GFC) are found to be common with high impact on early warning systems for both currency and systemic banking crises in Vietnam.

Using these EWS, we later calculate the probability series of currency and the systemic banking crisis in Vietnam with in-sample testing between January 2002 and December 2015 and out-of-sample testing for the period from January 2016 to December 2016 with a 24-month warning window. According to the out-of-sample analysis, the probability of observing both type of crises is found to be low.

Our results emphasise the impact of dollarisation in Vietnam's economy on the probability of having a currency or banking crisis. Worse, the same dollarisation also deteriorates the effectiveness of monetary policy transmission as well, in periods when it is most needed. Consequently, these currency or banking crisis might trigger excess demand from both households and the firms in the economy, eventually creating a vicious cycle of increasing volatility and increasing foreign exchange demand which further increases the local currency depreciation (leading to new currency crisis) and dollarisation. Therefore, this aspect should need a great attention.

Our findings also support evidence on the argument that the vulnerability of the banking sector in emerging countries have a significant impact on the foreign exchange market and may cause long-term currency turmoil. The study further reinforces the argument that the relation between the two types of crisis is bilateral,that is, exchange market pressures have significant impact on the likelihood of systemic banking crises in emerging countries such as Vietnam. The reason is that a simultaneous crisis event would cause a high cost in terms of decrease in real output and redistribution of wealth from taxpayers to bank depositors and bank stakeholders, whose funds were insured (or guaranteed) by the government.

Accordingly, in Vietnam, policymakers and regulators should take a prudential approach and regularly monitor the variability of the variables that can alert on the currency and systemic banking crises. If any of the variables are flagged, further analysis of the causes and their implications should be made so that policy adjustments can be taken into action in time to prevent crises. Furthermore, in order to limit the risk of currency and banking crises in Vietnam, policymakers need to pay attention to the exchange rate management, interest rate management, controlling money supply, increasing foreign exchange reserves, controlling the growth of domestic credit, control inflation, developing the stock market and boosting exports, tightening control of imports, increasing mobilisation of bank deposits and limiting the risk of bank operations in the banking system and continuing to fix dollarisation in the economy.

Unfortunately, the lack of updated macroeconomic data does not allow us to provide timely forecasts to support policy decision-making. Moreover, due to the unavailability of some data with a higher frequency than annual, our model could not cover some interesting variables related to the macroeconomic and public sector (e.g. institutional quality, terms of trade, short-term external debt, GDP, and real estate price indexes), and to the banking sector (e.g. return on total assets, return on equity, profitability, and non-performing loan). Another limitation is related to the use of the threshold and noise-to-signal ratios suggested by previous studies when applying the signal model, which

potentially reduces the accuracy of crisis predictions in the specific context of Vietnam. Future research could, therefore, improve the quality of our proposed early warning systems based on the road map of data availability improvement. More precisely, it is opportune to develop a more data-driven approach for establishing a threshold and noise-to-signal ratios for each of early warning indicators and then to examine their effectiveness over an out-of-sample period.

Notes

1. https://www.theglobaleconomy.com/Vietnam/bank_assets_GDP/.
2. https://www.adb.org/sites/default/files/publication/173663/fsi-viet-nam.pdf

Disclosure statement

No potential conflict of interest was reported by the author(s).

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