

Forecasting the Crisis of Vietnam's Financial Market by Markov Switching VAR Model

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Abstract: The global economy and financial markets have experienced "The most adverse shock in a century" due to the impact of the Covid-19 epidemic but are also transforming enormously in the digital era. Besides, Vietnam's financial system has been making vital development steps, increasing its resilience. Still, its development prospects depend mainly on the recovery of the global economy and financial markets, the Stability of the economy, and the Stability of the economic stability and sustainability of investor confidence in the market. The Markov Switching Var (MSVAR) model will measure the crisis in the Vietnamese financial system. The research goals reveal that the volatility of macro variables such as the exchange rate (ER), foreign exchange reserves (FR), and the domestic interest rate differential (ID) affects the financial market crisis in Vietnam from 2010 to 2020. According to MSVAR estimation, establishing the time of the financial market crisis correlates with the period of higher volatility in the foreign currency market. Thus, the article's novelty is to proactively seize opportunities development prospects and prevent risks towards sustainable development, and strategic solutions are needed.

Keywords: forecasting, crisis, financial, market, MSVAR, HUB.

马尔可夫切换向量自回归模型预测越南金融市场危机

摘要: 由于新冠肺炎疫情的影响, 全球经济和金融市场经历了“一个世纪以来最不利的冲击”, 但也在数字时代发生了巨大变化。此外, 越南的金融体系一直在迈出重要的发展步伐, 增强了韧性。不过, 其发展前景主要取决于全球经济和金融市场的复苏、经济的稳定性、经济稳定性的稳定性和投资者对市场信心的可持续性。马尔可夫切换向量自回归模型模型将衡量越南金融体系的危机。研究目标揭示了汇率、外汇储备、国内利差等宏观变量的波动影响越南2010-2020年的金融市场危机。根据马尔可夫切换向量自回归模型估计, 建立时间金融市场危机的发生与外汇市场波动较大的时期有关。因此, 文章的新颖之处在于主动把握机遇发展前景, 防范风险走向可持续发展, 需要战略性的解决方案。

关键词: 预测, 危机, 金融, 市场, 马尔可夫切换向量自回归模型, 胡志明银行大学。

1. Introduction

With the substantial increase in capital inflows following Vietnam's entry into the World Trade Organization (WTO) in November 2006, the country's financial markets became extremely attractive, allowing the Government to maintain a high capital surplus. The massive increase in international capital flows poses several threats to the financial system because of its negative repercussions, such as the values of financial assets, stock indexes, and the virtual growth in real estate prices [1, 2]. Vietnam is similarly in the euphoria stage before the crisis in the context of its membership to the WTO and the international financial market, with a lack of solid and timely warnings and measures for

risks at the micro and macro levels, as well as inexperienced investors and speculative psychology. Furthermore, a lack of preparation for the process of absorbing capital inflows, such as investment planning and appraisal, technology selection, and management training, has resulted in a reduction in the quality of investment when the effectiveness of investment programs and projects cannot keep up with the rate of capital inflows.

In the decade 2010-2020, Vietnam's financial market was highly volatile, with many risks arising from macroeconomic instability and external shocks such as the Covid-19 pandemic.

The financial crisis happens when the system's standard functions fail, and it is the most severe state of the financial system. Financial problems include currency crises, banking crises, and debt crises. A currency crisis occurs when an attack on the local currency causes a sharp drop in foreign currency reserves and a rapid domestic currency depreciation. Besides, forcing the regulatory authorities to intervene by using many foreign currency reserves to stabilize the exchange rate or raise interest rates. Currency crises can happen at the same time as or follow other problems. A banking crisis refers to a bank's liquidity when it no longer has enough financial resources to meet creditors' or lenders' withdrawal needs. The banking system can repay loans when the present value of the debt exceeds the current value of the assets, causing the bank to go bankrupt [3, 4]. A debt crisis occurs when a country cannot fulfill foreign loans, including government and private sector debts, and must offer to renegotiate debt agreements and defer payment of interest and principal.

Financial crises had produced by (i) economic structure, (ii) financial system internal difficulties, and (iii) macroeconomic policy, finance, and policy response. International organizations such as the IMF and other central banks have established a system of indicators to monitor the financial system due to these factors. These are known as financial safety indicators. To analyze the current status of financial safety and develop quantitative models to monitor the financial system, such as the early warning system (EWS) model and the stress test model [5, 6].

Creating a quantitative model system can aid economists and policymakers in precisely predicting the likelihood of future financial system crises. Various approaches had to apply to construct early warning models (EWS) of economic instability and currency crises with varying degrees of success.

This article examines the Markov Switching Vector Autoregressor (MSVAR) application with time-varying transition probability (TVTP) as an early warning model. This multi-chain model outperforms single-chain, probit, and logit models in terms of performance.

2. Literature Review

2.1. Financial Market Concept

The financial market is a market for trading financial assets such as stocks, bonds, bills, etc. Participants in financial market transactions include households, businesses, and financial institutions. The central intermediaries and the Government are the participants in the buying and selling financial assets and commodities in the financial markets [7, 8].

An economy that wants to develop must first meet the needs of investment capital. It is necessary to increase savings. This concept is the causal relationship between savings and investment and is the foundation

for socio-economic development and expansion of production and business construction accounting.

The need for capital to invest and savings can arise from different actors in the economy. Those with profitable investment opportunities lack money, and idle capital has no investment opportunities [9].

Need capital in the economy through buying, selling, and transferring financial and financial assets. That capital movement had carried out in the financial market. The financial market had considered a place to focus on mobilizing capital sources in society for entities' short, medium, and long-term financing [7, 10].

The existence of financial markets is an indispensable element of the market. The financial assets here can be equity instruments that confirm the contribution of entities such as stocks. This factor can also be debt instruments to record a loan such as bonds, bills, and Derivative financial instruments such as forward contracts, options contracts, swaps [3]. In essence, when the exchange of goods appeared, the cash flow appeared in parallel thanks to contradiction.

2.2. Functions of Financial Markets

Function to stimulate savings and investment, where is the best place to study accounting in Vietnam?

The function of price formation of financial assets. The process of creating liquidity (Cashability) for financial assets [11, 12]. Financial markets act as a conduit for capital from savers to traders. They are helping to move the money from people who do not have profitable investment opportunities to those with good investment opportunities [13].

The financial market promotes the accumulation and concentration of capital to meet the needs of building technical and material foundations, production, and business chief accountant degree [12].

Financial markets make capital more efficient, not only for those who have money to invest but also for those who borrow money to invest. The lender will profit through the interest rate on the loan. Borrowers must calculate the most effective use of that loan because they have to repay both capital and interest to the lender and must generate income and accumulate for themselves.

The financial market creates favorable conditions for implementing the Government's economic reform and opening-up policies through issuing bonds abroad, selling shares, attracting foreign investment capital outside the domestic production and business industries. The function provides financial information and assesses the value of the business [7, 12].

2.3. Financial Crisis

A financial crisis is a financial market crash. Financial markets cannot move capital as efficiently as before for specific reasons. This factor leads to a recession in the economy. In other words, a financial crisis is when financial corporations lose their liquidity.

This factor led to a chain collapse in the financial system [2, 5].

The financial crisis was commonly applied to describe situations where financial institutions or financial assets lose most of their value. A financial crisis occurs when financial markets crash caused by adverse selection and moral hazard become acute in financial markets, rendering these markets incapable of capital mobility - efficiency from savers to potential investors. The result was an economic downturn [10, 14].

2.4. Studies Related

Research shows a monetary policy rule that uses the exchange rate to stabilize the economy in managing macroeconomic fluctuations [8]. The differences between the administrations are driven by: the paths of the nominal exchange rate and the interest rate under each rule and external habits in consumption, which leads to deviations from uncovered interest parity. Utilize the time-varying parameter VAR model with stochastic volatility to examine the impact of uncertainty on capital flows. Findings strongly confirm that the effect of uncertainty shock on capital flows is slight. In contrast, speculative wonder plays a vital dominant role in capital movement resulting in a currency crisis [15].

They applied the deep learning method in the TVP-VAR model under systematic financial risk monitoring and early warning. The results indicate that the dynamic weighted financial condition index based on the time-varying parameter vector autoregressive model includes five variables: interest rate, real estate price, money supply, exchange rate, and stock price. TVP-VAR model also proves that the degree of fiscal tightening and financial market conditions can be measured and warned by changes in economic indicators. This model validates China's economic situation from 2013 to 2017 [12, 16].

We have considered Markov-switching models with covariate-dependent transition functions subject to exogenous discrete stochastic changes. These changes are associated with simultaneous stochastic changes in the covariance structure of the observable variables. Simulation experiments had carried out to assess the quality of large-sample approximations to the distributions of the maximum-likelihood estimator and related statistics in such a model and examine the implications of misspecification due to unaccounted breaks in the transition mechanism [2].

This research investigates the effects of the financial stress index (FSI) of developed countries on the exchange market pressure index (EMPI) of Brazil, China, Mexico, Russia, South Korea using the nonlinear vector autoregression (VAR) model and quantile-based analysis. The authors found the effects of FSI depletion on the EMPI for lower EMP regimes. The nonlinear VAR found that increases/decreases in the FSI of

developed countries will increase/decrease the EMPI in each emerging country. On the other hand, allowing the role of regime changes, the quantile regression model revealed that a raise in the FSI of developed countries might cause an increase in the EMPI during their high-EMP periods [17].

This paper assesses several early warning (EWS) models of financial crises to propose a model that can predict the incidence of a currency crisis in developing countries. The research employs equal weighting (EW) and dynamic model averaging (DMA) approaches to combine forecasts from individual models allowing for time-varying weights. Taking Egypt as a case study and focusing only on currency crises, Research findings show that combined forecast (EW and DMA-based EWS), to account for uncertainty, perform better than other competing models in both in-sample and out-of-sample predictions [9].

Propose a new framework for measuring connectedness among financial variables arising from heterogeneous frequency responses to shocks. Economically, periods in which connectedness had created at high frequencies are when stock markets seem to process information rapidly and calmly. A surprise to one asset in the system will impact the short term. When the connectedness had created at lower frequencies, it suggests that shocks are persistent and had transmitted for more extended periods. To estimate connectedness in short, medium, and long-term financial cycles, introduce a framework based on the spectral representation of variance decompositions [18].

The research aims to identify leading indicators of a currency crisis in Viet Nam based on an early warning system for the period 1996–February 2016. Global financial shocks and domestic credit growth rate are leading indicators of a currency crisis in Vietnam in all three models. Deficits in the trade balance, international reserves, and overvaluation of the dong are also good indicators. In addition, a model in which a currency crisis or turbulence in the foreign exchange market is defined based on the exchange market pressure and parallel market premium, with a window length of 2 months, outperformed for predicting a currency crisis in Vietnam. Empirical results suggested that the probability of predicting a genuine currency crisis was 77.5% [6].

Exports are an essential factor in preventing currency crises. An intuitive and straightforward formula captures an economy's structural vulnerability characterized by the elasticity of exports and repayments for foreign currency-denominated debt. Research shows that the possibility of currency crisis equilibrium depends on this structural vulnerability and analyzes how this vulnerability impacts the effectiveness of monetary policy response [19].

The globalization process has led to a high economic and financial interdependence across countries

worldwide. Shocks occurring in a specific market seem to spread to other countries. Therefore, financial interdependence creates contagion, especially under massive country-specific shocks [20].

The author had estimated the chance of a sudden stop in capital inflow in developing market economies. A twenty-five-basis point increase in the ratio of foreign exchange reserves to short-term external debt is considered the same effect as a 1% increase in the current account balance (as a percentage of GDP) [20].

Research shows that rising global inequalities and the uncontrolled development of the US mortgage and housing markets have profoundly destabilized the economy, with various shocks impacting equity markets and macroeconomic variables. Based on multivariate Markov-switching models, this research presents new results on the interactions between global imbalances, credit spreads, housing markets, macroeconomic variables, commodities, and equities during Q1-1987/Q1-2011 [21].

The crisis likelihood of the global financial crisis of 2008-2009 had evaluated by Frankel and Saravelos [22]. Foreign exchange reserves, real exchange rate, credit growth, real GDP growth, and current account balance to GDP are reliable indicators for predicting the likelihood of a crisis. The findings of this study support the theory that the volume of foreign exchange reserves is negatively and substantially associated with the extent of a problem [20]. The significant cumulative value of national foreign exchange reserves reduces economic vulnerability.

The research created a multiple logit regression EWS model that predicts emerging market economies better. The author evaluated parametric and nonparametric EWS for a sample of 20 nations from January 1970 to April 1995 in their study. The results suggest that parametric EWS models outperform nonparametric EWS models in signal generation. The authors determined the cut-off probability value in these experiments subjectively. To assess indicators for currency crises in 28 emerging market economies, compare parametric and nonparametric EWS models. As a result, the parametric EWS model gives better out-of-sample prediction results than the nonparametric EWS models [18, 21].

When investigating central banks' general exchange rate policy, demonstrated that using the volatility of foreign currency reserves as a Markov series is appropriate. This study employs the exchange rate, foreign currency reserves, and interest rate differential simultaneously [23].

East Asian crisis used monthly data for Asian countries from 1972 to 1999 and found that the Markov-switched model significantly improved projections. Furthermore, the authors used Markov-switching with propagation variables incorporated in the transition probability (TVTP - Time-Varying Transition Probability) to demonstrate that the currency crises in

Korea and Thailand exacerbated Indonesia's financial situation [6].

The authors examined the volatility of macroeconomic and financial variables in 15 developing and five developed nations in the years 1970-1995. When the variable crosses a certain threshold level, an alert signal is generated, defined by the ratio of correct signals (successful forecasting of currency crises) to wrong signals (inaccurate forecasts of the currency crisis). The authors utilized this model to evaluate the period leading to the Asian financial crisis in 1997-1998 [6, 12].

The currency crisis happens when the local currency depreciates by more than 25% compared to the previous year. The depreciation rate is greater than 10% compared with last year (does not consider the effect of inflation). The ISP found a linear combination of exchange rates, foreign exchange reserves, and interest rate differentials from the equivalent interest rate in USD or EUR. Composite indicators had commonly used [24, 25].

The authors used data from 20 developing countries to run a regression to figure out what caused the Mexican peso crisis. from 23 developing nations to investigate the Asian financial situation using the above methodology employed probit regression to examine the

The European monetary area from 1960 to 1992 was the first to adopt the ISP index. The probit model had also been utilized [6, 20]

3. Methods of Research

3.1. Dataset

Understanding the financial markets will provide tremendous opportunities to invest financially and earn profits. The database utilized in the study had applied data from Rifinitiv Datatreams, the General Statistics Office of Vietnam, the Ministry of Finance of Vietnam, and the State Bank of Vietnam, totaling 44 observations for each variable from the first quarter of 2010 to the fourth quarter of 2020. Besides, decisions, business strategies, and how businesses operate in the current 4.0 era depend heavily on databases - factors capable of bringing high accuracy and providing helpful information for policy managers. The above is the most basic information to overview this extraordinary market segment briefly.

Table 1 The definition of variables

Short Name	Variable
Exchange rate (ER)	The exchange rate is a measure of international competitiveness. He is raising its foreign exchange reserves to better prepare for a sudden reversal
Foreign exchange reserves (FR)	of international capital flows or currency attacks, which in principle should reduce financial vulnerability for its firms and the entire economy.

Continuation of Table 1

Interest rate domestic (ID)	The actual lending rate (ILR) had calculated by subtracting the expected inflation rate from the lending rate (%). Domestic interest rates affect domestic credit, foreign exchange rates, and exports.
FDI growth (FDI)	FDI investment growth is dependent on the economy's stability (including the financial system).
LIBOR	Libor was widely used as a reference rate for many financial instruments in financial markets and commercial fields.
Money supply (M2)	The accurate money supply (M2) represented the monetary policy and had calculated by dividing the nominal money supply by the GDP deflator.
Money supply (M2)/ FR	This indicator measures the central bank's ability to meet the demand for foreign currency in a crisis by displaying the level of external debt secured by foreign currency in the banking system.
Export ratio	A change in the value of exports can signal an overvaluation of the local currency.
Domestic credit (DCR)	Domestic credit provided by the financial sector as a percentage of GDP
GDP growth (GDP)	The real GDP (Y) value is derived using 2010 constant prices.

In table 1, the author used the following variables: The real exchange rate (ER) represents the current value of the Vietnamese dong (VND), volatility in forex reserves (FR) represents the central bank's efforts to regulate the market, and the domestic interest differential (ID) is viewed as a factor influencing investors' and speculators' decisions, reflecting the domestic market's attractiveness. Specific variables such as the real exchange rate, FDI inflow growth rate, LIBOR, M2 ratio, foreign exchange reserve ratio, M2 to foreign exchange reserves ratio (M2/FR), export ratio, domestic credit to GDP ratio, and GDP calculated the volatility of three macro variables. The remaining variables employ the Tramo/Seats approach to adjust seasonality except the interest rate.

3.2. Research model

The Markov series model assumes that a value's volatility in the next period had determined by its volatility in the preceding period. This model is consistent with the probability of a crisis occurring when the financial system, central banks, and investors react to volatility in one period by making decisions in the next. As a result, research utilizing the Markov series frequently considers the variation of a value chain over time as a VAR model, which can be multivariable [2].

The Markov Switching VAR-TVTP model, on the other hand, does not use the threshold value; instead, it regresses the state obtained from MSVAR according to the macro indicators in the previous period to find the relationship between the condition in period (t) and the variables in period (t-1). It gives a crisis prediction

probability from the period indices (t-1). The ISP index calculation component variables are used as Markov series to measure financial market volatility [4, 22].

The study uses a time-varying state transition probability dependent on a set of macroeconomic factors in each period to consider the exchange rate and the ISP index in two cases: turbulent and ordinary.

Markov switching VAR (MSVAR)

The MSVAR model that has been proposed is as follows:

$$Y_t = \alpha_0(S_t) + \alpha(S_t) y_{t-1} + \sigma(S_t) \eta_t,$$

where $\eta_t \sim N(0,1)$

In which:

Y: endogenous variables vector

S: binary variable

α : Alpha

σ : Sigma

η : Eta

t: the state at the time (t)

t-1: the state at the time (t -1).

Y_t is a vector with endogenous variables that are components of the ISP index, including the change in nominal exchange rate ΔER , the change in foreign exchange reserve ΔFR , and the change in interest differentials ΔID , all of which have two states: turbulent and ordinary. In which

ΔER : the difference in the exchange rate;

ΔFR : the change in foreign exchange reserves;

ΔID : the shift in interest differentials.

4. Research results

4.1. Descriptive Statistics

Descriptive statistics for the variables ER, FR, and ID in Vietnam for the period 2010-2020 had shown in Table 2.

Table 2 Testing of descriptive statistics

Index	ΔER	ΔFR	ΔID
Mean	0.0032	0.0172	-0.1278
Median	0.0006	0.0141	0.0000
Maximum	0.0732	0.2114	13.9700
Minimum	-0.0587	-0.1084	-32.0558
Std. Dev.	0.0107	0.0504	2.4689
Skewness	2.7794	0.7557	-9.5891
Kurtosis	26.0654	4.5156	140.4136
Jarque-Bera	4902.052	39.8938	167638.1
Probability	0.0000	0.0000	0.0000
Sum	0.6586	3.5858	-26.7415
Sum Sq. Dev.	0.0239	0.5284	1267.811
Observations	132	132	132

Table 2 shows that the ISP is affected by the following variables: nominal exchange rate at the time (t), foreign exchange reserves at the time (t), and interest rate differential between the domestic currency and foreign currency at the time (t).

While the nominal exchange rate represents the current value of the local currency (VND), volatility in foreign exchange reserves represents central bank adaptations to market regulation and interest

differentials. The domestic interest rate had considered a variable was the decisions of investors and speculators, showing the attractiveness of the domestic financial market.

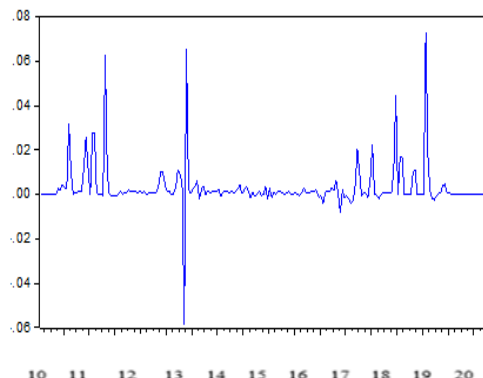


Fig. 1 Testing ΔER in Vietnam in the period 2010-2020

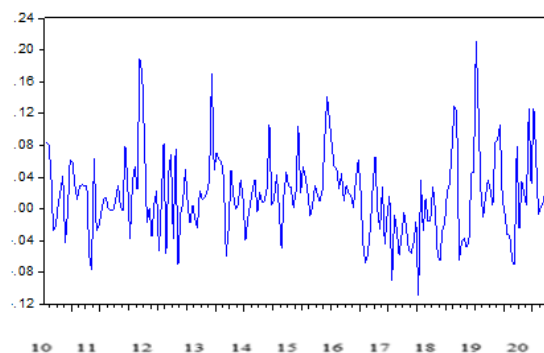


Fig. 2 Testing ΔFR in Vietnam in the period 2010-2020

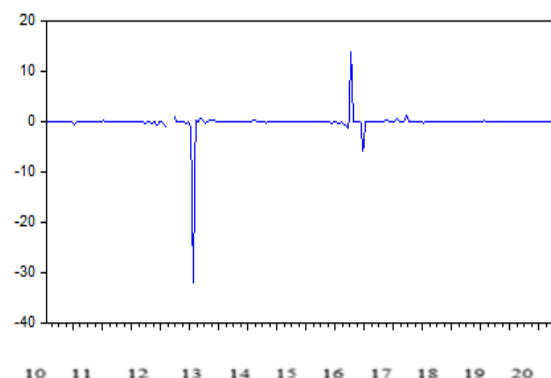


Fig. 3 Testing ΔID in Vietnam in the period 2010-2020

In a period of speculative pressure, if a slight change in the exchange rate corresponds to a substantial shift in foreign exchange reserves, it represents the central bank's policy to protect the currency in the country.

Table 3 shows that the MSVAR results give an estimate for each observation of the probability of falling into each turbulent and ordinary state, thereby simultaneously establishing the state variable S_t . $S(t=1)$ if the period is tumultuous, and $S(t=2)$ if the period had expected. Figs 1, 2, and 3 showed that foreign exchange reserves (FR) are more volatile than the exchange rate (ER) and domestic interest rate differential (ID) over the period 2010-2020. In 2010-2020, the interest rate differential (ID) had had positive volatility. This result is considered a solution to reduce speculative pressure.

Table 3 Testing MSVAR estimator for turbulent – ordinary state

MSVAR – Turbulent			
$S_{(t=1)}$	$\Delta ER(-1)$	$\Delta FR(-1)$	$\Delta ID(-1)$
ΔER	-0.0435	-0.2064	0.0213
ΔID	0.4048	-0.4011	-0.1427
ΔFR	-0.0839	0.2653	-0.0560
α_0	71.6147	99.1350	23.8071
MSVAR – Ordinary			
$S_{(t=0)}$	$\Delta ER(-1)$	$\Delta FR(-1)$	$\Delta ID(-1)$
ΔER	0.4179	-0.0700	0.0139
ΔID	0.0740	-0.5270	0.2410
ΔFR	0.0127	0.3614	-0.0383
α_0	43.8301	103.2683	45.2989

Table 4 Regression of turbulent times through MSVAR

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-343.9938	117.6915	-2.9228	0.0035
DCR(-1)	-6.03E-13	1.86E-13	-3.2453	0.0012
M2(-1)	-6.83E-14	2.12E-14	-3.2215	0.0013
M2/FR(-1)	0.000632	0.0002	3.0224	0.0025
FDI(-1)	1.05E-08	3.48E-09	3.0105	0.0026
EXPORT(-1)	6.15E-09	2.14E-09	2.8736	0.0041
ER(-1)	0.0202	0.0072	2.7985	0.0051
LIBOR(-1)	2.6358	1.0327	2.5522	0.0107
FR(-1)	-6.80E-10	2.89E-10	-2.3571	0.0184
M2/FR(-1)	-42.8306	20.1396	-2.1266	0.0334
DCR/GDP(-1)	7.33E-09	3.50E-09	2.0925	0.0364
McFadden R-squared	0.6916	Mean dependent var		0.1162
S.D. dependent var	0.3214	S.E. of regression		0.1967
Akaike info criterion	0.3495	Sum squared resid		6.2325
Schwarz criterion	0.5508	Log-likelihood		-19.064
Hannan-Quinn criter.	0.4312	Deviance		38.1294
Restr. Deviance	123.6491	Restr. log-likelihood		-61.824
LR statistic	85.5196	Avg. log-likelihood		-0.1108
Prob(LR statistic)	0.0000			
Obs with Dep=0	112			
Obs with Dep=1	20			

Table 4 showed that the study used the log model with St. states determined from the MSVAR model to regress the probability that a period is a turbulent period according to the macroeconomic indicators of the previous period at a significance level of 5% the following results. The estimation results from the MSVAR model give a discriminant probability that the turbulent and ordinary states differ very clearly for all periods, which helps to indicate the $St \rightarrow$ state of that period. St is just a volatile and nonvolatile state variable of the MSVAR model, which does not necessarily mean the time of a financial crisis.

Probability of turbulent times: The probability of the period (t) having a rough state when the previous period (t-1) has an intermediate state is defined as p_{01} , p_{ij} and defined as the probabilities of a period at state j when the last period at the state i.

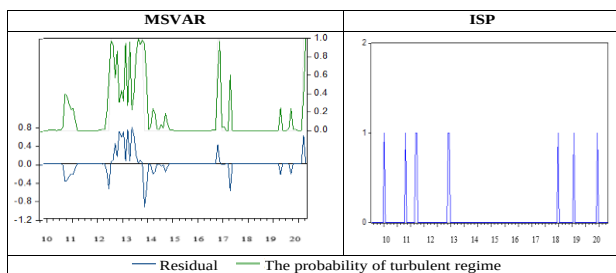


Fig. 4 Estimated crisis period probability from MSVAR and ISP

Fig. 4 examined the predictability of MSVAR for financial market volatility in Vietnam. The study compares the forecast results of a period of variation between two estimates: Estimation from the MSVAR model: $P(\text{turbulent}) = P(St=1/xt-1)$. The threshold for ISP: $P(\text{turbulent}) = P(ISP > \tau)$. Where τ is a given threshold, specifically, here the stage called crisis had proposed threshold of 1.5, that is, if: $\text{empty} > \beta \cdot \text{comp} + \mu \text{emp}$ with $\beta = 1.5$, a period is called a crisis.

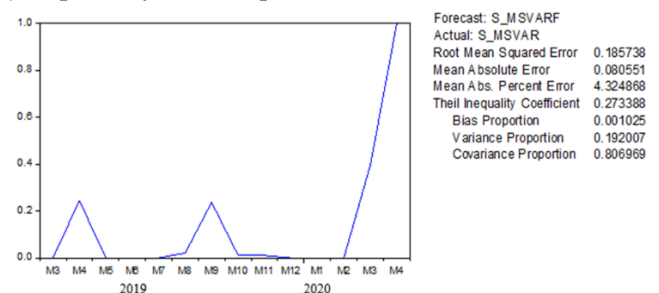


Fig. 5 Forecast from MSVAR probability volatility period

Fig. 5 shows that MSVAR recognizes periods of volatility in the foreign exchange market, as shown in Fig. 4. The MSVAR model recognizes times of higher volatility with a longer duration when compared to establishing the crisis period based on the ISP threshold. MSVAR with the probability of turbulent regime found more association of crisis period with macro variables (ER, FR, ID) than Probit model using ISP threshold. MSVAR gives the probability of a crisis is more sensitive than the Probit model based on the crisis

threshold and is more favorable for policy management in volatile periods, but not necessarily when the financial crisis occurs.

MSVAR is used in the regression estimating approach of the probability of a turbulent regime based on macroeconomic variables (ER, FR, ID), which determines crisis probability based on an ISP crisis threshold, with similar results for the period 2010-2020. For the remaining times, however, it has a different value. Using the MSVAR model with ISP from the log function, the volatility period forecast obtained an error percentage of approximately 4.32%.

5. Conclusions and Policy Implications

5.1. Conclusions

The research results showed that the use of the MSVAR model gave the ability to predict with high accuracy the volatility (turbulent and ordinary) of macroeconomic variables of the economy. By finding the relationship between periods of financial market volatility and macro variables such as ER, FR, ID, it has been shown that MSVAR's results exploit the amount of information from volatility in these indices. Precisely: real exchange rate, FDI inflow growth rate, LIBOR interest rate, M2 money supply ratio, foreign exchange reserve ratio, money supply M2 to foreign reserves, export rate, domestic credit rate/GDP, and GDP.

The MSVAR model had meant to forecast the state of the economy derived from the macroeconomic variables of the previous period, helping to increase the capacity of the early warning of the financial market crisis warning model. Following financial market volatility in the period 2010-2020, the variables ER, FR, and ID had considered in correlation with each other. The MSVAR model with Time-Varying Transition Probability (TVTP) helps detect turbulent periods in the financial market, helping to manage monetary policy. If appropriate and timely policies are in place, a period of financial market turmoil does not necessarily turn into a financial market crisis. However, the research is limited because it has not yet developed a transition policy for each state (turbulent and ordinary) of the Vietnamese financial market. Vietnam's financial system has been making vital development steps, and its resilience is increasing. Still, its development prospects depend mainly on the recovery of the global economy and financial markets and its stability. There are stability and sustainability of investor confidence in the market. Therefore, to proactively seize opportunities and development prospects and prevent risks towards sustainable development, strategic solutions are needed.

5.2. Policy Implications

The article discussed these significant results from macro-management perspectives and identified opportunities and challenges for Vietnam's global financial system; therefore, some strategies to help

Vietnam take advantage of solutions, overcome challenges, increase resilience, and develop sustainably.

The financial-banking sector needs to be completed and effectively implemented. Accordingly, the author should consider the amendment of the Law on State Bank, Law on Credit Institutions, Law on Deposit Insurance. The Securities Law 2019 (effective January 1, 2021) had implemented and must complete the Law on Insurance Business (allowing the financial group model). Projects such as the Banking Sector Development Strategy to 2025 (Decision No. 986/QĐ-TTĐ dated August 8, 2018); Green finance and green banking development strategies need to be developed and deployed from central to local levels.

The legal corridor for new business models in the digital economy and finance - digital currency and green finance. They included a pilot management mechanism) need to be completed soon to facilitate operations of fintech companies, new business models such as sharing economy, Blockchain application, AI, cloud computing... Besides, the author should quickly build a fintech Center selected in Ho Chi Minh City because 60% of fintech companies and fintech clubs had located). In addition, a task force to study CBDC trends and Vietnam's approach had established. At the same time, revealing the process of developing Vietnam's green financial system to 2030, with a vision to 2045, should soon be built with four main pillars: green financial intermediaries, green capital mobilization tools, and green investment enterprises and green banks.

The author should enhance the capacity for management, supervision, safety, and stability of the financial-monetary system. Accordingly, the State Bank and other management and supervisory agencies need to be more independent and empowered. The author must build a systematic risk management and monitoring model, a financial-monetary stability model, and a crisis handling mechanism. Inspection and supervision tools and forms had modernized. Violations in the market require strict sanctions. In addition, the effectiveness of policy coordination (especially between monetary policy and fiscal policy) should continue to improve to achieve efficiency in interest rate policy, medium and long-term capital mobilization, promote the upgrading process of Vietnam's stock market. Policy credits and commercial credits need to be separated to increase the autonomy ownership in the operation of financial institutions. The set of indicators to assess the degree of the greening of the financial system (green banks, green investments, green securities, the group of corporate sustainability index - SSI, and the set of general green economic indicators - GFI) need formed to define the evaluation criteria.

Modern information technology is critical. Management agencies need to proactively develop and consistently implement a Digital Transformation Strategy in the financial - banking sector, including building and standardizing databases, building digital

human resources and public infrastructure. In addition, the project to upgrade Vietnam's stock market also needs to be developed and implemented, in which transparency, professionalism, diversification of products and services, especially risk management support products, are essential. The managers must give digital financial products and green finance special attention. In addition, financial literacy had disseminated to raise people's awareness of using digital financial services and develop green finance as a pillar of the financial inclusion strategy by 2030.

The research limitation does not study the quality of providing information and transparency in the market is still far from international; financial intermediaries' corporate governance, risk management, and financial capacity are still limited. In addition, Vietnamese accounting standards still have many differences that have not kept up with international accounting standards, creating loopholes for some organizations to take advantage of wrong accounting transactions.

The legal framework for the operation of the market is incomplete and has not kept up with the development of the market. In addition, the level of application of information technology in the financial system is still low. It has long-distance compared to many countries in the region. And the world's information technology development. Based on the above limitations, the following research provides information and transparency.

References

- [1] BOLLERSLEV G. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 1986, 3(1): 307-327. [https://doi.org/10.1016/0304-4076\(86\)90063-1](https://doi.org/10.1016/0304-4076(86)90063-1)
- [2] JOZEF B., & TOMÁŠ K. Measuring the Frequency Dynamics of Financial Connectedness and Systemic Risk. *Journal of Financial Econometrics*, 2018, 16(2): 271-296. <https://doi.org/10.1093/jfinec/nby001>
- [3] ENGLE H. Dynamic conditional correlation: A simple multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, 2020, 20(3): 339-350. <https://www.jstor.org/stable/1392121>
- [4] IBRAHIM B. Inter-regional and region-specific transmission of international stock market return: The role of foreign information. *Journal of International Money and Finance*, 2019, 2(8): 322-343. <https://ideas.repec.org/a/eee/jimfin/v28y2009i2p322-343.html>
- [5] BAKSHI C. Inflation, asset prices, and the term structure of interest rates in monetary economics. *Economic Development and Cultural Change*, 1996, 9(1): 241-275. <https://www.jstor.org/stable/2962371>
- [6] ZACHARIAS P., & MARTIN S. Markov-Switching Models with State-Dependent Time-Varying Transition Probabilities. *Econometrics and Statistics*, 2021, 12(3): 165-176. https://ideas.repec.org/p/udt/wpecon/2017_01.html
- [7] ANZHONG H., LENING Q., and ZHENG L. Applying deep learning method in TVP-VAR model under systematic financial risk monitoring and early warning. *Journal of Computational and Applied Mathematics*, 2021, 382(15): 113-125. <https://doi.org/10.1016/j.cam.2020.113065>
- [8] BUSSIERE M., & MARCEL F. Towards a New Early Warning System of Financial Crises. *Journal of International Money and Finance*, 2018, 2(5): 953-973. <https://doi.org/10.1016/j.jimonfin.2006.07.007>
- [9] JULIEN C. Global imbalances, cross-market linkages, and the financial crisis: A multivariate Markov-switching analysis. *Economic Modelling*, 2019, 29(3): 943-973. <https://doi.org/10.1016/j.econmod.2012.02.012>
- [10] DOUGLAS K., TIM W., and ANSON W. Do the uncertainty-induced capital outflows matter in currency crisis? Evidence from the Hong Kong speculative attacks. *Finance Research Letters*, 2021, 39(3): 101-113. <https://doi.org/10.1016/j.frl.2020.101643>
- [11] BAKER B., & DAVIS G. Measuring economic policy uncertainty. *Journal of Monetary Economics*, 2018, 131(4): 1593-1636. <https://doi.org/10.1093/qje/qjw024>
- [12] FRANKEL J., & ANDREW, R. Currency Crashes in Emerging Markets: An Empirical Treatment. *Journal of International Economics*, 2018, 4(1): 351-366. [https://doi.org/10.1016/S0022-1996\(96\)01441-9](https://doi.org/10.1016/S0022-1996(96)01441-9)
- [13] COMELLI G. F. Comparing Parametric and Non-parametric Early Warning Systems for Currency Crises in Emerging Market Economies. *Journal of Banking and Finance*, 2019, 3(4): 123-134. <http://dx.doi.org/10.1111/roie.12121>
- [14] RYOTA N. Structural vulnerability and resilience to currency crisis: Foreign currency debt versus export. *The North American Journal of Economics and Finance*, 2017, 42(3): 132-143. <https://doi.org/10.1016/j.najef.2017.07.009>
- [15] OGUZHAN O. B. Assessing the impacts of financial stress index of developed countries on the exchange market pressure index of emerging countries. *International Review of Economics & Finance*, 2020, 70(3): 288-302. <https://doi.org/10.1016/j.iref.2020.07.012>
- [16] JONASHEIPERTZ I., & ANA M. Managing Macroeconomic Fluctuations with Flexible Exchange Rate Targeting. *Journal of Economic Dynamics and Control*, 2022, 21(1): 124-135. <https://doi.org/10.20955/wp.2017.028>
- [17] GEORGE S. K. Can Leading Indicators Assess Country Vulnerability? Evidence From the 2008-09 Global Financial Crisis. *Journal of International Economics*, 2019, 8(7): 216-231. <https://doi.org/10.1016/j.jinteco.2011.12.009>
- [18] TORNELL A. V. Financial Crises in Emerging Markets. *American Economic Review*, 2020, 8(9): 328-332.
- [19] KAMINSKY G. L., SAUL, L., and CARMEN M. R. Leading Indicators for Currency Crisis. *Journal of Econometrics*, 2018, 7(3): 127-147. <https://www.imf.org/external/pubs/ft/wp/wp9779.pdf>
- [20] KAMINSKY G. L., & REINHART C. M. The Twin Crises: Causes of Banking and Balance-of-Payments Crises. *American Economic Review*, 1999, 89(3): 473-500. <https://www.jstor.org/stable/117029>
- [21] YAROVAYA B. L. Intra and inter-regional return and volatility spillovers across emerging and developed markets: Evidence from stock indices and stock index futures. *International Review of Financial Analysis*, 2016, 43(3): 96-114. <https://doi.org/10.1016/j.irfa.2015.09.004>
- [22] MAMDOUH A. M., & HANYABDEL L. An optimal early warning system for currency crises under model uncertainty. *Journal of Economic Dynamics and Control*, 2020, 12(5): 385-423.

<https://doi.org/10.1016/j.cbrev.2020.03.002>

[23] FRANKEL J., & GEORGE S. Can leading indicators assess country vulnerability? Evidence from the 2008–09 global financial crisis. *Journal of International Economics*, 2012, 87(2): 216-231.

<https://doi.org/10.1016/j.jinteco.2011.12.009>

[24] WU F. D. Measuring the macroeconomic impact of monetary policy at the zero lower bound. *Review of Economic Studies*, 2018, 5(8):195-209.

<https://www.nber.org/papers/w20117>

[25] ZHAO S., & OXLEY R. Extreme value modeling for forecasting market crisis impacts. *Applied Financial Economics*, 2020, 20(2): 63-72.

<http://dx.doi.org/10.1080/09603100903262947>

参考文献:

[1] BOLLERSLEV G. 广义自回归条件异方差。计量经济学杂志, 1986, 3(1): 307-327. [https://doi.org/10.1016/0304-4076\(86\)90063-1](https://doi.org/10.1016/0304-4076(86)90063-1)

[2] JOZEF B., 和 TOMÁŠ K. 衡量金融连通性和系统性风险的频率动态。金融计量学杂志, 2018, 16(2): 271-296. <https://doi.org/10.1093/jfinec/nby001>

[3] ENGLE H. 动态条件相关: 一个简单的多元广义自回归条件异方差模型。商业与经济统计杂志, 2020, 20(3): 339-350. <https://www.jstor.org/stable/1392121>

[4] IBRAHIM B. 国际股票市场回报的跨区域和区域特定传输: 国外信息的作用。国际货币与金融杂志, 2019, 2(8): 322-343. <https://ideas.repec.org/a/eee/jimfin/v28y2009i2p322-343.html>

[5] BAKSHI C. 通货膨胀、资产价格和货币经济学中的利率期限结构。经济发展与文化变迁, 1996, 9(1): 241-275. <https://www.jstor.org/stable/2962371>

[6] ZACHARIAS P., 和 MARTIN S. 具有状态相关时变转移概率的马尔可夫切换模型。计量经济学和统计学, 2021, 12(3): 165-176. https://ideas.repec.org/p/udt/wpecon/2017_01.html

[7] ANZHONG H., LENING Q., 和 ZHENG L. 系统金融风险监测预警下的时变参数-向量自回归模型模型中的深度学习。计算与应用数学杂志, 2021, 382(15): 113-125. <https://doi.org/10.1016/j.cam.2020.113065>

[8] BUSSIÈRE M., 和 MARCEL F. 迈向新的金融危机预警系统。国际货币与金融杂志, 2018, 2(5): 953-973. <https://doi.org/10.1016/j.jimonfin.2006.07.007>

[9] JULIEN C. 全球失衡、跨市场联系和金融危机: 多元马尔可夫转换分析。经济建模, 2019, 29(3): 943-973. <https://doi.org/10.1016/j.econmod.2012.02.012>

[10] DOUGLAS K., TIM W., 和 ANSON W. 不确定性引起的资本外流在货币危机中是否重要? 来自香港投机攻击的证据。金融研究快报, 2021, 39(3): 101-113. <https://doi.org/10.1016/j.frl.2020.101643>

[11] BAKER B., 和 DAVIS G. 衡量经济政策的不确定性。

货币经济学杂志, 2018, 131(4): 1593-1636. <https://doi.org/10.1093/qje/qjw024>

[12] FRANKEL J., 和 ANDREW, R. 新兴市场的货币崩盘: 实证处理。国际经济学杂志, 2018, 4(1): 351-366. [https://doi.org/10.1016/S0022-1996\(96\)01441-9](https://doi.org/10.1016/S0022-1996(96)01441-9)

[13] COMELLI G. F. 比较新兴市场经济体货币危机的参数和非参数预警系统。银行与金融杂志, 2019, 3(4): 123-134. <http://dx.doi.org/10.1111/roie.12121>

[14] RYOTA N. 货币危机的结构脆弱性和弹性: 外币债务与出口。北美经济与金融杂志, 2017, 42(3): 132-143. <https://doi.org/10.1016/j.najef.2017.07.009>

[15] OGUZHAN O. B. 评估发达国家金融压力指数对新兴国家外汇市场压力指数的影响。国际经济与金融评论, 2020, 70(3): 288-302. <https://doi.org/10.1016/j.iref.2020.07.012>

[16] JONASHEIPERTZ I., 和 ANA M. 通过灵活的汇率目标管理宏观经济波动。经济动态与控制杂志, 2022, 21(1): 124-135. <https://doi.org/10.20955/wp.2017.028>

[17] GEORGE S. K. 领先指标能否评估国家脆弱性? 来自2008-09年全球金融危机的证据。国际经济学杂志, 2019, 8(7): 216-231. <https://doi.org/10.1016/j.jinteco.2011.12.009>

[18] TORNELL A. V. 新兴市场的金融危机。美国经济评论, 2020, 8(9): 328-332.

[19] KAMINSKY G. L., SAUL, L., 和 CARMEN M. R. 货币危机的领先指标。计量经济学杂志, 2018, 7(3): 127-147. <https://www.imf.org/external/pubs/ft/wp/wp9779.pdf>

[20] KAMINSKY G. L., 和 REINHART C. M. 这双重危机: 银行和国际收支危机的原因。美国经济评论, 1999, 89(3): 473-500. <https://www.jstor.org/stable/117029>

[21] YAROVAYA B. L. 新兴市场 and 发达市场的区域内和区域间回报和波动溢出: 来自股指和股指期货的证据。国际金融分析评论, 2016, 43(3): 96-114. <https://doi.org/10.1016/j.irfa.2015.09.004>

[22] MAMDOUH A. M., 和 HANYABDEL L. 模型不确定下的货币危机最优预警系统。经济动态与控制杂志, 2020, 12(5): 385-423. <https://doi.org/10.1016/j.cbrev.2020.03.002>

[23] FRANKEL J., 和 GEORGE S. 领先指标能否评估国家脆弱性? 来自2008-09年全球金融危机的证据。国际经济学杂志, 2012, 87(2): 216-231. <https://doi.org/10.1016/j.jinteco.2011.12.009>

[24] WU F. D. 在零下限衡量货币政策的宏观经济影响。经济研究回顾, 2018, 5(8):195-209. <https://www.nber.org/papers/w20117>

[25] ZHAO S., 和 OXLEY R. 用于预测市场危机影响的极值模型。应用金融经济学, 2020, 20(2): 63-72. <http://dx.doi.org/10.1080/09603100903262947>