

# ANALYZING THE GLOBAL MACROECONOMIC INFORMATION FLOW TO VIETNAM'S STOCK PRICE INDEX: AN APPROACH USING ENTROPY TRANSFER

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## ABSTRACT

With the robust development of econophysics, this article applies the transfer entropy computational method to analyze the direction of movement and measure the impact of information flow between international macroeconomic factors and the Vietnamese stock market, represented by the VN-Index. Data for the Vietnamese stock market index and international macroeconomic indicators, including those of the United States, China, the European Union, and Singapore, were collected monthly from January 2001 to June 2024. The research results show that Vietnam is an information absorber, primarily from the two powers, the United States and China. Besides, Vietnam also transmits information to certain countries, but the transmission signals are unclear and lack statistical significance. These research findings allow policymakers to develop appropriate market management and regulatory policies. Furthermore, domestic and foreign investors can create investment strategies to make effective and optimal investment decisions based on market volatility forecast trends.

**Keywords:** *information flow, international macroeconomic factors, transfer entropy approach, Vietnamese stock market.*

## 1. Introduction

In the history of research, many scholars have been interested in and carried out empirical works related to the measurement of the influence and transmission of information flow of foreign factors to the economic strength of a country. This is extremely important for Government agencies, policymakers, and especially foreign investors in making initial predictions on the performance of the country's financial markets. However, with the trend of international integration becoming more and more popular, the relationship and impact of other countries' information on the domestic economy has become more complex and difficult to measure. Meanwhile, traditional quantitative methods have some disadvantages such as operating based on assumptions and certain conditions that have led to research results that differ greatly from reality. Meanwhile, the development of economic physics has opened a new approach as transfer entropy is increasingly widely applied in many fields such as computer science, information on social networks, economic dynamics, and especially in financial time series (Mao & Shang, 2017). Compared to traditional approaches, transfer entropy can reflect the information relationship between time sequences, identifying the source and target sequences in this information relationship but not depending on the linear relationship hypothesis between the sequences (Trần Thị Tuấn Anh, 2021; Haken & Portugali, 2016; Osei & Adam, 2020). Although this new approach has brought positive research results in the world, this one is still relatively new to Vietnamese scholars as there have not been many studies applying transfer entropy to measuring information between random variables. The main objective of this study is to analyze and measure the impact of

foreign information flows on the Vietnamese financial market, and to assess the influence of international economic factors on the volatility of the domestic financial market. Based on modern economic physics, the study examines the ability of the transfer entropy method to quantify the power and transmission of information from some countries to the Vietnamese financial market. At the same time, the study aims to propose policies to improve the ability to forecast and manage risks in national financial markets. This study is based on a data sample of macro indices and financial market returns of key international markets such as the United States, China, the European Union, and Singapore, which have a great influence on Vietnam's financial markets. The data sample is carefully selected macro indicators to ensure the representation of the factors that have a real impact on the financial markets. These indices are collected from reputable data sources and published officially every year such as the World Bank, The Federal Reserve (FED), and the Ho Chi Minh City Stock Exchange (HOSE). To have enough data and reflect the nature of the market, the research period starts from 2001 to June 2024.

## **2. Literature review**

Studies on the impact of information flow between countries or the impact between components in the financial market have always been a topic of great interest to scholars. According to the study of Osei and Adam (2020), there is always an interaction and exchange of information between national economies. The stock market is considered a non-isolating system that interacts with and exchanges information with the real economy. Information flows between the stock market, the stock market, and its components, as well as other financial markets. For the most part, key markets such as the US, the EU, China, etc. will often exert strong influences on smaller markets with policy changes (Hamao et al., 1990; Kim & Rogers, 1995; Le & Kakinaka, 2010). In addition, the group of scholars Abdul Karim and Shabri Abd. Majid (2010) has found that cultural, and geographical proximity and close relations between countries are the driving force as well as the cause of the influence of information flows into the stock market of underlying countries. In particular, the events that interact and lead to volatility between stock markets are often based on two general theories including traditional theory and theory based on investor psychology (Aawaar et al., 2017).

Traditional theory is developed based on basic principles and relationships in the economy. In particular, the volatility of different stock markets in the same period has no friction and investors are rational. This co-movement is created by the fluctuations of macro factors of countries. Thus, when countries share or depend on each other for macroeconomic factors, their stock markets are likely to have co-volatility. Meanwhile, the theory based on investor psychology takes a different approach, arguing that stock market changes are based on the existence of friction in economies. This means that the co-volatility of the underlying economic factors does not necessarily reflect the co-volatility of the stock market. Instead, investor psychology and behavior are seen as core, including emotions and expectations, which can impact the markets, causing them to move together even when there is no fundamental change in economic factors (Barberis et al., 2005). Throughout the history of research, parametric econometric models have been widely used to deal with problems related to the detection and measurement of interactions between countries' financial markets. Typically, the relationship of information between markets is studied by various econometric techniques. Some common techniques are applied such as Pearson correlation, vector autoregressive model (VAR), vector error correction model (VECM), Granger multiplication test (Trần Thị Tuấn Anh, 2021; Granger, 1969; Nyakurukwa, 2021). In addition, Chang and Su (2010) also showed that autoregressive conditional heteroskedasticity (ARCH) and generalized

autoregressive conditional heteroskedasticity (GARCH) are the models used by many quantitative researchers.

The scholar Giovannini and Jorion (1987) shows that raising interest rates will negatively affect the development of the financial market and the foreign exchange market. The research of Ali (2014) in Pakistan found that the higher the interest rate, the lower the stock market's performance. This is mainly because the attractiveness of investors will decline when they can earn higher returns by investing in safe channels such as bonds or bank deposits, instead of having to take risks when investing in financial markets. In addition, new results are Panda (2008) found when providing evidence that interest rate has an impact on the price of the stock in both the short and long term. Short-term interest rates will have a positive impact on stock market volatility, while long-term interest rates create a negative impact. The link between stock prices and inflation has been intensively studied since the 1990s. Most studies in industrialized economies have shown a negative relationship between stock market returns and inflation. Research results of Ahmed et al. (2015) demonstrated that there is a unilateral causal relationship between inflation and the Bangladesh stock market in the short term. Meanwhile, a group of Spanish scholars del Camino Torrecillas and Jareño (2013) studied the relationship between information on inflation and the stock market in Spain. This group of scholars emphasizes that inflation information will have a negative impact in the short term on stock returns, but this relationship becomes positive in the long term. For the relationship between exchange rates and the stock market, Andreou et al. (2013) use the VAR-GARCH model with the scope of research in twelve emerging economies to examine the extent of information spillover between the foreign exchange market and between emerging stock markets. In particular, the stock market and exchange rates have a two-way spillover effect. However, the study of scholars Xie et al. (2020) suggests that only the stock's information is really meaningful in predicting the exchange rate and does not have the opposite effect. With the E-Garch approach, Andreou et al. (2013) show that there is no consistent relationship between the Indian financial market and macro factors such as exchange rates, money supply, and interest rates. For the M2 money supply, the increase in the money supply will facilitate the increase in liquidity and the expansion of credit for stock investors, thereby leading to an increase in the stock market price (Friedman & Schwartz, 2008). In addition, when the money supply curve shifts to the right, interest rates tend to decrease, causing the cost of borrowing to decrease. This effect will encourage investment and consumption, boosting the demand for shares, and thereby creating more upward pressure on the stock market.

However, traditional techniques are formulated and operate on the assumption that the relationship between a time series of returns of stock markets is linear and is a normal distribution (Trần Thị Tuấn Anh, 2021; Haken & Portugali, 2016; Osei & Adam, 2020). Otherwise, scholar Trần Thị Tuấn Anh (2021) also pointed out another drawback of the traditional approach when the parameter model cannot determine the source and destination of the flow of information between countries. To overcome these disadvantages, many scholars around the world have experimented with a new approach named transfer entropy of physical economics. Transfer entropy was first introduced by the researcher Schreiber (2000) to measure dependence and analyze the direction of information transmission between the transmitting and receiving variables. In addition to the ability to operate effectively without relying on complex assumptions and following basic stochastic procedures, this technique is also capable of processing non-parametric data on directed information transmission and displaying information asymmetry between research subjects (Nyakurukwa, 2021). From that, this new technique is expected by many scholars to work out the

limitations of communication methods such as the VAR model, Granger causal model, etc. While the Granger causality test can be extended to handle nonlinear datasets, the transfer entropy approach is simpler and more convenient (Trần Thị Tuấn Anh, 2021). Moreover, the entropy transfer technique does not depend on parametric statistical tests such as Granger tests and other traditional models.

In the research of Marschinski and Kantz (2002), these authors analyzed the information flow between Dow Jones and Dax markets using the transfer entropy approach. The result of this study has obtained positive results by providing reliable evidence of the flow of non-linear information between two major markets. Therefore, this is considered an important milestone for future research. The scholars He and Shang (2017) applied transfer entropy to the analysis of stock indices of three major markets including the United States, the Europe, and China within twenty years. In particular, the United States and China are two countries with strong information transmission and could create a clear influence on other markets. The scientific report of Kwon and Yang (2008) selected a broader analysis, with a sample of 25 countries from different geo-economic regions. However, the results of these two reports both indicate that the United States is the country that plays the role of transmitting important information to other markets. Vietnam is no exception when the study of Tien Thuan (2011) found that the United States influences Vietnam, namely that the flow of positive information from the S&P 500 is statistically significant to the fluctuations in the profitability of the VN-Index.

In addition to studies related to the movement of information between markets, many scholars around the world also experimented with the application of transfer entropy to analyze the flow of information between enterprises in the stock market of a country. The academic team of Baek et al. (2005) researched the direction of information spread between listed enterprises of many industries in the United States. The result of this research shows that the United States stock market is mainly governed by the flow of information from the top enterprises in terms of capitalization and energy companies. Similarly, the group of scholars Yue et al. (2020) also learned about the transfer of information between listed enterprises on the two stock exchanges of the United States and China with the transfer entropy approach. Non-financial companies in China and tech unicorns in the United States are the most active adopters of information in these two major markets. In Korea, the flow of information between industrial sectors has a clear level of asymmetry, and in particular, the insurance sector is the main source of transmission information during the subprime lending crisis (Oh et al., 2014). The study of Kwon and Oh (2012) used the transfer entropy method to measure the flow of information between the market index and stocks, showing that information from the market index has a stronger impact on stocks. This asymmetry takes place in both developed and emerging markets but is stronger in developed markets. In contrast to the above study, the empirical results of Behrendt et al. (2019) show that the level of information influence of constituent stocks on the market index is higher.

In Vietnam, the concept of applying transfer entropy to information flow analysis studies is still scarce and has many limitations. Which, the researcher Trần Thị Tuấn Anh (2021) has applied the transfer entropy approach to survey the flow of information from foreign economies to the Vietnamese stock market. The results of this study show that Vietnam is a country that receives information from the United States and China strongly. In addition, the information from the spot gold market also significantly affects the VN-Index with a two-day delay, but the Vietnam market is not affected by the information about the crude oil market. Besides, the scholar Trần Thị Tuấn

Anh (2023) also used the calculations of transfer entropy to be able to analyze the direction of information movement between different sectors in the Vietnamese financial market. The level of information transfer between industries will have different delays and all information flows will become discreet after five days. In addition, transfer entropy has also been Truong Thị Thùy Dương (2024) used in measuring the flow of information from the financial market to the gold spot market and the results show that information from the US market has had an extremely strong impact on Vietnam.

Overall, the results show that transfer entropy has effectively overcome the disadvantages of the communication method as well as this approach has also met the provision of information transmission power and information flow between markets or between market components. However, the number of studies applying this technique in Vietnam to the analysis and measurement of information is still limited. Therefore, this article aims to use transfer entropy in analyzing the flow of global macroeconomic information to the Vietnamese stock market to have more basis to introduce this new approach to domestic scholars.

### 3. Data and research methodology

#### 3.1. Data

This report uses monthly data of VN-Index's return and macro indicators including inflation (CPI), exchange rate, interest rate, and M2 money supply from some markets in the world such as Singapore, the United States, China, European Union. The data used for this research were collected over 23 years, from January 2001 to June 2024. The research data are collected from official sources such as HOSE, FED, and World Bank (details in [Table 1](#)).

#### 3.2. Research methodology

Based on information theory, transfer entropy was first introduced worldwide by Schreiber (2000) as a new method that measures the level of information transfer between random variables based on a probability density function. Transfer entropy is conditional mutual information, where the past values of the influenced variable Y are included in the conditioning set (Dobrushin, 1963; Wyner, 1978). Accordingly, when the information flows from variable X to variable Y exists, this means that the data of X in the past can be used to make the right predictions to the current information of variable Y with the formula:

$$TE_{X \rightarrow Y} = I(Y_{t-1:t-L} | X_{t-1:t-L}) \quad (1)$$

Where,  $Y_{t-1:t-L}$  and  $X_{t-1:t-L}$  are the set of past information of variables Y and variable X in the period from t-1 to t-L, respectively. If the result of the transfer entropy calculation  $TE_{X \rightarrow Y}$  is larger, this means that more information is transmitted from X to Y and vice versa. In the case of  $TE_{X \rightarrow Y}$  close to zero or zero, the information flow of the variables does not interact. In addition, transfer entropy is not symmetrical, so the level of information transmission from X to Y may be different from the amount of information transferred from Y.

However, common entropy approaches such as Rényiian entropy and Shannonian transfer entropy are flawed when it is not possible to separate noisy information flows from the calculation results. Therefore, effective transfer entropy is considered a method of overcoming the disadvantages in the data transmission process, especially with small data samples. The mechanism of action of effective transfer entropy was Marschinski and Kantz (2002) developed by the academic team based on the calculation of normal transmission entropy, but with the

addition of time series shuffling of the source variable to generate random samples (Nyakurukwa, 2021). During the shuffling process, the data series of the source variable is randomly rearranged several times to break the temporal relationships in the data. As the size of the study sample grows, the calculated value of the disturbed transfer entropy will gradually converge to 0 as described in the formula (2).

$$TE_{X_{shuffled} \rightarrow Y} \rightarrow 0 \text{ when } N \rightarrow \infty \quad (2)$$

The effective transfer entropy value is calculated by subtracting the average of the transfer entropies from the disturbance chain from the initial transfer entropy value, specifically:

$$Eff. TE_{X \rightarrow Y} = TE_{X \rightarrow Y} - TE_{X_{shuffled} \rightarrow Y} \quad (3)$$

## 4. Research results

### 4.1. Descriptive statistics

The study data includes 282 observations with factors of VN-Index returns, macro indicators such as interest rates, exchange rates, inflation, and money supply (M2) of China, the US, the EU, and Singapore markets in the period 2001-2024, which are detailed in [Table 2](#). The profit of the VN-Index has a small average value, showing that the Vietnamese financial market in the research period tends to increase slightly. However, the large standard deviation index (0.0913) reflects the high volatility of our country's market during this period. In addition to domestic factors, foreign impacts are also part of the volatility of the developing market and rapid integration like Vietnam. Statistically, the United States is a country with higher interest rate fluctuations than other countries. In which, EU interest rates have periodically fallen below zero percentage, reflecting the trend of loose monetary policy to stimulate economic growth in the context of uncertainty. In terms of exchange rates, the euro and yuan are highly volatile, while the dollar is the most stable foreign currency for Vietnam. In this period, inflation in China, the EU, and US has a relatively similar level of volatility. However, the level of inflation fluctuations in Singapore is larger than in the rest of the study sample.

### 4.2. Results of information flow testing using transfer entropy approach

In this study, the scholar considers both directions of the flow of information from the foreign macro factors to the Vietnamese stock market and vice versa. First of all, to have an overall view of the relationship between foreign macro factors affecting Vietnam, the author has visualized the relationship between the Vietnamese stock market and international macro indicators as well as checked the correlation matrix results. Overall, international macro factors have different impacts on the return of VN-Index. The visualized results from [Figure 1](#), [Figure 2](#), [Figure 3](#), and [Figure 4](#) show that interest rates and inflation in most countries create the opposite impact on Vietnam's financial markets. In addition, data from the correlation matrix shown in [Figure 5](#) show that the correlation between Vietnam and macro factors of the US and China is relatively clearer than other markets. This also means that any information related to these two markets can significantly affect the Vietnam financial market. In particular, the negative correlation between the VN-Index and some macro factors of the United States such as the central interest rate and exchange rate shows that the Vietnamese stock market will face many pressures when the FED decides to raise interest rates, and the dollar strengthens. This is perfectly consistent with both theory and practice. As the Vietnamese market no longer becomes attractive in terms of profitability and businesses face pressure from the dollar, foreign investors are mostly inclined to rotate international capital out of

emerging markets such as Vietnam back to the host country. Notably, the correlation matrix results partly show that there is harmony in the macro fluctuations of major economies. In addition, some factors such as Singapore interest rates have a fairly high positive correlation with US interest rates and EU interest rates, suggesting that Singapore's monetary policies may be influenced by these major economies. However, the VN-Index is not affected too much by other countries' interest rates or monetary policies, except the US and China. In general, the correlation matrix has shown that there is a link between the Vietnamese market and international macro variables.

To analyze the direction of movement and measure the level of information transmission from one variable to another, the author calculates transfer entropy by RStudio software. The results of the transfer entropy calculation in [Table 3](#) show the research purpose of the authors when it clearly shows the trend of information flow from major economies in the world including the United States, China, the European Union (EU), and Singapore to developing markets such as Vietnam. The author recognized that Vietnam is the country that receives most of the macro information from the countries in the scope of this study. Macro factors from the US and China have a significant influence on the VN-Index, while many factors from other countries such as Singapore and Europe have a lower impact or no information transmission at all. The experimental results in [Table 3](#) reflect that information derived from the two factors of central interest rate and inflation of the United States has the strongest impact on the Vietnamese financial market when the transfer entropy results of these two factors are high and statistically significant. In addition, money supply and Chinese inflation also have a significant impact, confirming the importance of the Chinese economy to the volatility of the Vietnamese market. This also reflects the close relationship between Vietnam's economy and major financial markets such as the US, especially after trade relations agreements between our country and these two superpower countries.

In contrast, some macro factors have lower transfer entropy values and do not reach high levels of statistical significance such as the Chinese exchange rate and the European exchange rate. This means that the information relationship between the exchange rates of these countries and the VN-Index is unclear. Notably, interest rate and money supply factors from Singapore, Europe, and China all showed no significant impact, with entropy values being zero or very low and not reaching statistically significant levels. This shows that Vietnam's financial markets are not significantly affected by the macro factors of these regions. Thus, in terms of economic significance, the macro information of the above countries can be used to forecast information about Vietnam's financial market. Especially the two largest markets in the world, the United States and China, when the transfer entropy results showed that Vietnam's stock market depends mainly on information and volatility from major economies such as the US and China. Our result is also completely consistent with previous experimental studies of several domestic and foreign scholars such as (Trần Thị Tuấn Anh, 2021; He & Shang, 2017; Kwon & Oh, 2012).

The transfer entropy approach is not symmetrical. If the result of transfer entropy is larger, it means that there is strong information flow propagation from one random variable to another random variable. However, information transferred in reverse between random variables may be different. Therefore, to be able to answer the research question about whether the Vietnamese market transmits information to other major countries, the author checks the results of the transfer entropy calculation of the Vietnamese financial market to other markets in [Table 4](#). In terms of calculation results, the level of information transmission between the Vietnamese market and the macroeconomic factors of other countries is uneven, mainly in Singapore. However, transfer



entropy values are very low as well as most are not statistically significant. This partly reflects that the level of information transmission of Vietnam to these countries is unclear, and it is difficult to conclude that information from our country's stock market can impact other markets. For the US market, information from Vietnam does not affect the macro economy of this superpower country at all. This result can be explained by the limited level of interaction between Vietnam's financial markets and global economic factors, as well as the fact that Vietnam's financial markets have not yet played an important role in influencing international economic variables.

In conclusion, information flows from other countries in the world significantly have a transmission and impact on the performance of Vietnam's stock market. The results from [Table 3](#) và [Table 4](#) reflect that Vietnam is a country that absorbs information more than it transmits it. Our country absorbs information mainly from the two largest economies in the world, the United States and China. Information about Vietnam's market has been transferred to a few countries, but the level of influence is unclear. The results of this study also completely coincide with some previous studies in the country (Trần Thị Tuấn Anh, 2021; Trương Thị Thùy Dương, 2024).

## **5. Conclusion and policy implications**

### **5.1. Conclusion**

The study used the transfer entropy calculation method to measure and analyze the flow of information moving between the Vietnamese financial market and the macro indices of the United States, China, the EU, and Singapore. From the perspective of the information-receiving market, Vietnam is the country that absorbs information on international macro factors within the research sample, mainly information from the United States and China. At the same time, the transfer entropy results also show that Vietnam transmits information to other countries, but the amount of information and the level of influence of information flow in Vietnam is not strong and clear. From these findings, understanding the flows of information moving between markets helps investors and managers better grasp volatility trends, thereby developing investment strategies as well as adjusting market management policies more appropriately and effectively in the context of global economic integration.

### **5.2. Policy implications**

Research results have shown that the use of the transfer entropy calculation method has many outstanding advantages over other methods of measuring information transmission, especially in the context of analyzing nonlinear relationships between economic or financial systems. Based on the research results, the author also gives some policy implications that can be developed and help this approach become more popular.

Firstly, transfer entropy is a powerful tool for measuring information transmission in nonlinear systems and does not depend on assumptions. With the development and change in the period of digital transformation, the information relationship between markets has become increasingly complex and non-linear. The application of transfer entropy replaces other traditional methods to provide researchers, investors, and policy administrators with more reliable and accurate results on information transmitted between markets or economies.

Second, transfer entropy can be applied in various fields such as economics, finance, biology, and social networks to analyze complex systems. Its wide applicability has made it an ideal tool for studying information relationships between countries and developed economies. In addition, this method is not only suitable for temporal data but also can be applied to spatial data



and other types of data. Therefore, policymakers need to facilitate researchers from many different disciplines to collaborate, and share data as well as methods, thereby promoting the application of transfer entropy in multidisciplinary contexts.

Third, transfer entropy can be used to analyze data in real-time, enabling timely detection of changes or information transmission between systems. This is important in the context of financial economics, where decisions often have to be made quickly based on sudden market changes. Therefore, policymakers and investors can use the calculation results of transfer entropy as a basis for making business decisions in addition to considering domestic factors. In particular, the flow of macro information from the two markets of the United States and China needs to be paid more attention than other markets.

### **5.3. Limitations and research orientation**

#### **5.3.1. *Limitations***

Firstly, the model has not yet considered the transmission at different latencies. This study assumes information is transmitted between countries with the same latency. However, the fact is that the delay in the transmission of economic information can vary from country to country, depending on many factors such as the economic structure, the financial system, the monetary policy of each country, or the degree of connection to the global market.

Secondly, the data was performed in some typical countries without considering the transmission levels in some other countries, especially Asia. This limits the ability to comprehensively analyze the interaction between Vietnam and different economic sectors.

Thirdly, the current research focuses mainly on the direct impact between macro indicators but ignores the effects of indirect information transmission between countries or between variables through other intermediaries. This can reduce the accuracy in accurately capturing the information interaction of the economic interaction network.

Finally, this study does not consider the milestones that change the world economic cycle or the effects of external economic shocks such as financial crises, geopolitical fluctuations, etc. on the transmission of information between countries.

#### **5.3.2. *Research orientation***

First of all, model correction and further consideration of the effects of indirect transmission is one of the core directions that should be taken to improve research results. This process includes a combination of transfer entropy and machine learning models, or applying other methods such as dynamic transfer entropy to track and analyze the change of information transmissions over time. Thereby, the macro relationship will be expressed more clearly under the variation of time and related variables.

Secondly, it is necessary to analyze the impact of information flows of international macro factors on the Vietnamese financial market at different latency intervals. The change over time of economic variables is the decisive factor in assessing the effectiveness of economic and financial policies. In addition, with the policy and the level of relations between Vietnam and other countries, information delays will also differ.

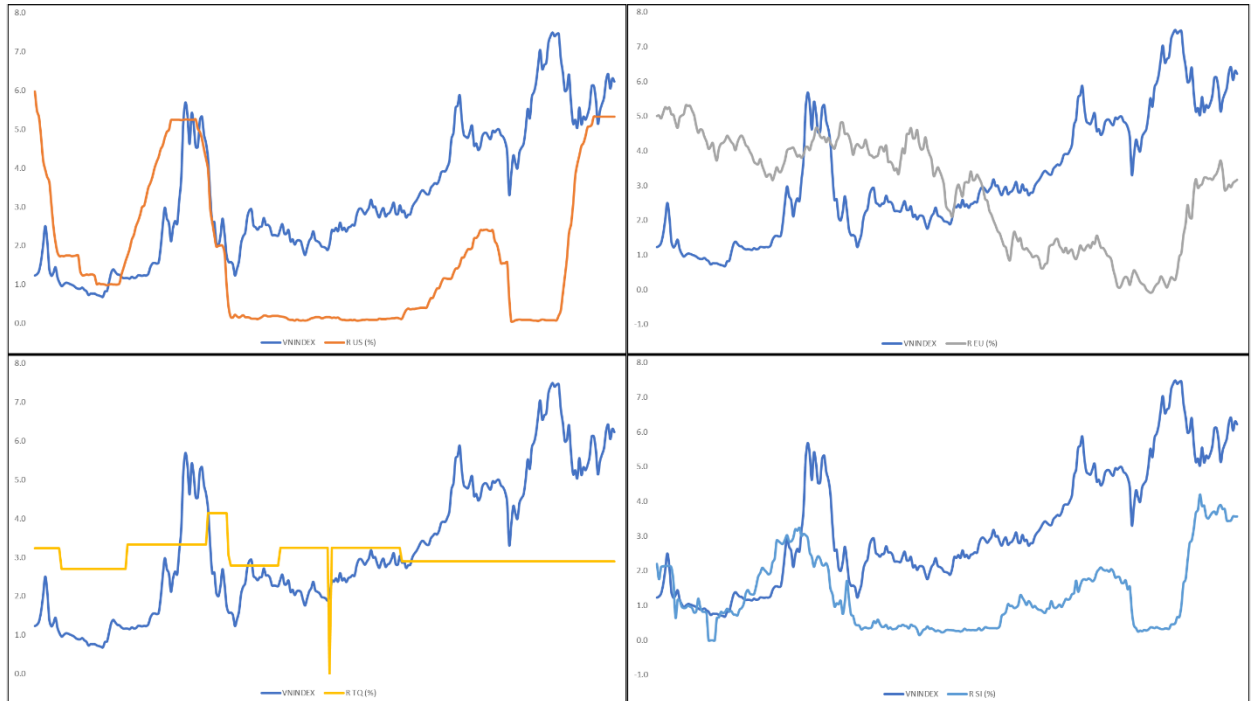
Third, expanding different macro variables from many countries in diverse economic sectors such as developed countries, emerging markets, and countries with special economies to help

create a more comprehensive picture of global information transmission. Differences in economic structure and degree of international cohesion can lead to different responses to the same economic shock.

Last but not least, it is necessary to combine further analysis of important events such as financial crises, material price fluctuations, gold price fluctuations, political events, etc. The addition of these factors will assist in better anticipation and interpretation of sudden changes in information flow transmission.

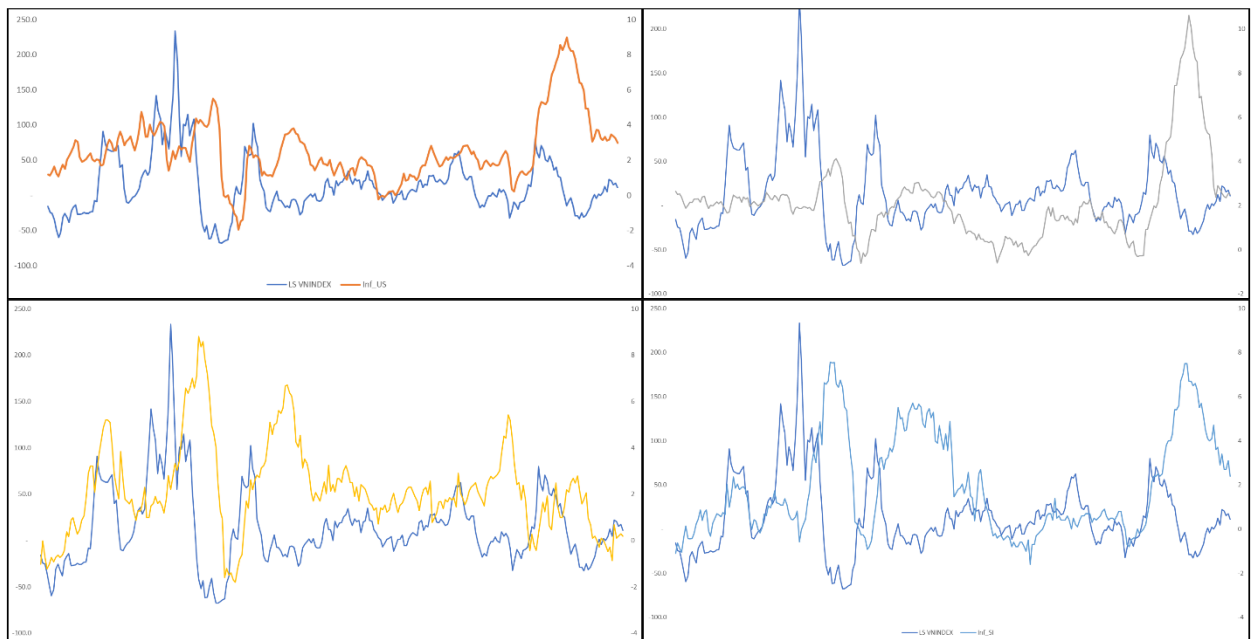
## APPENDIX

### Appendix 1. Graphs, Figures



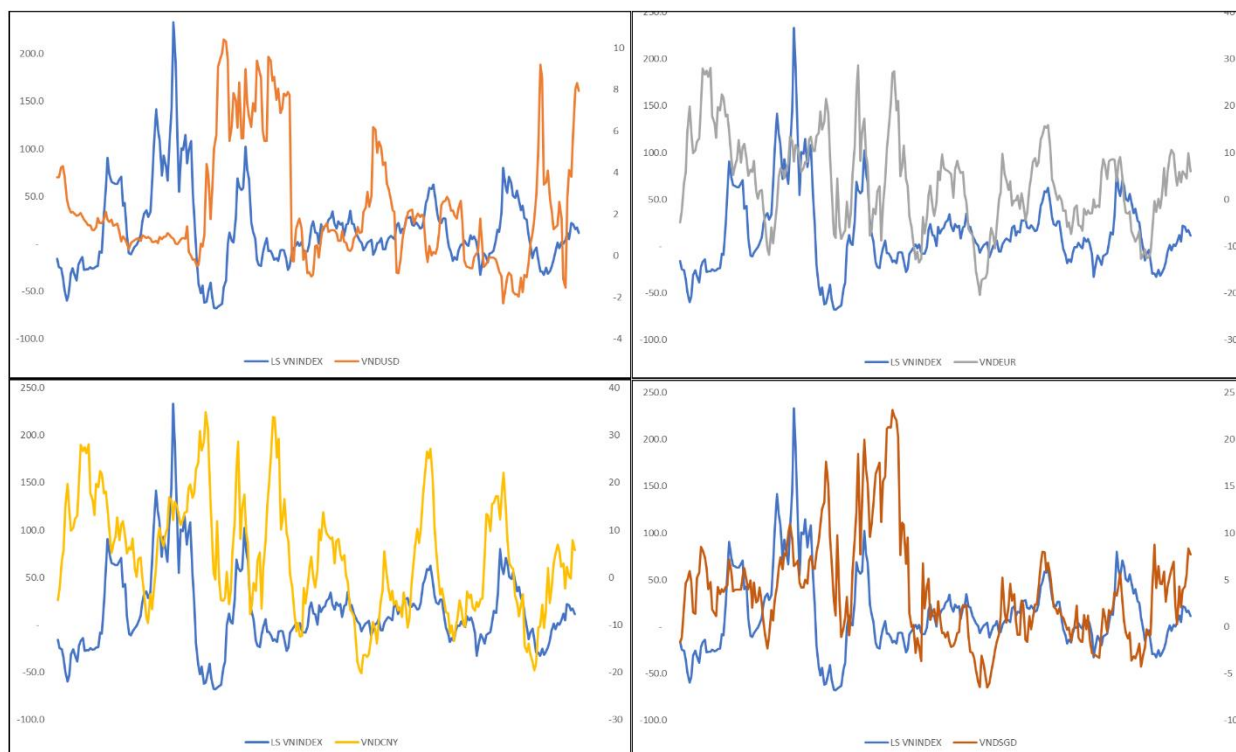
**Figure 1. Movement of VN-Index and interest of foreign countries**

*Source: Author's calculation*



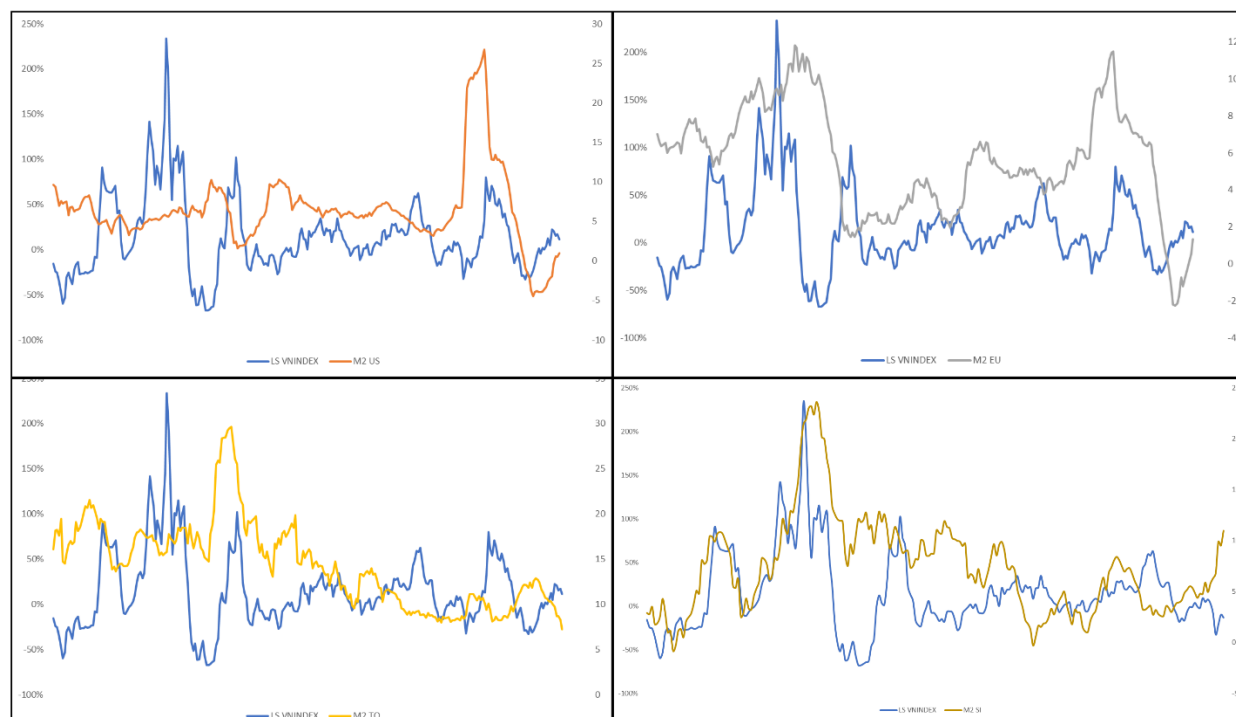
**Figure 2. Movement of VN-Index and inflation of foreign countries**

*Source: Author's calculation*



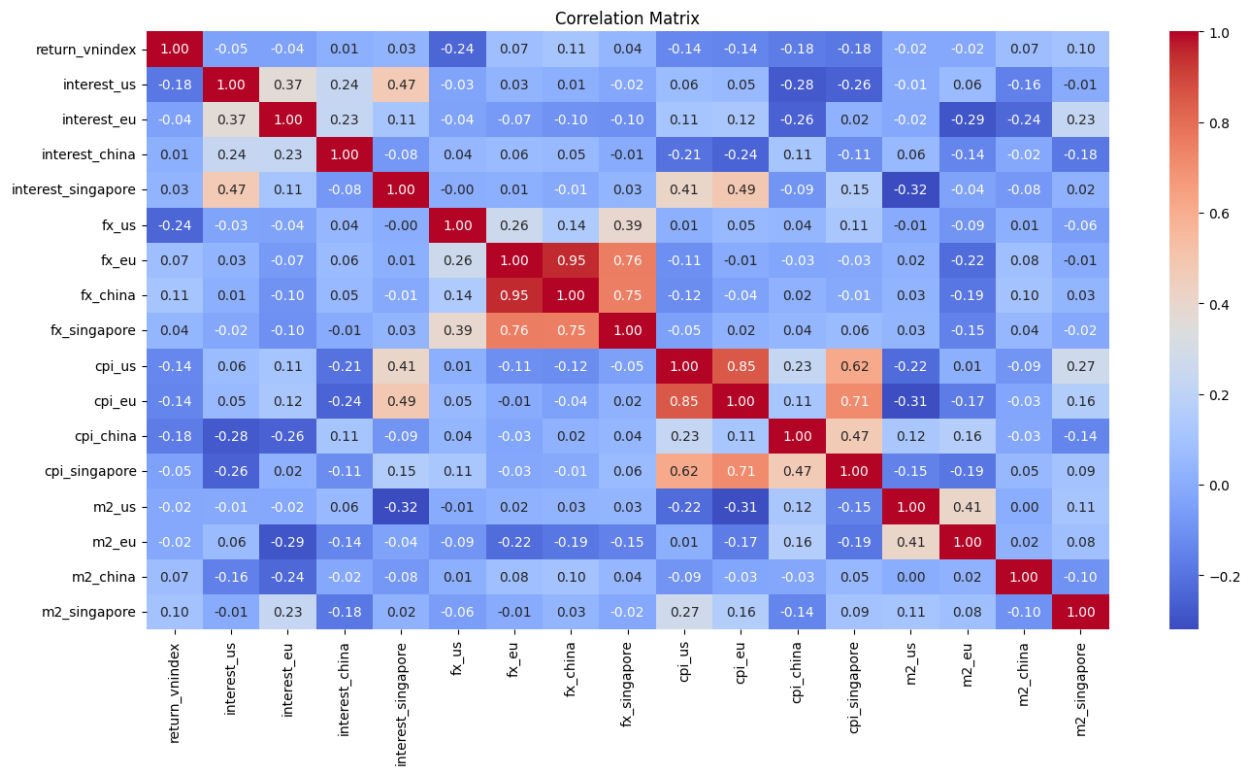
**Figure 3. Movement of VN-Index and foreign exchanges of foreign countries**

*Source: Author's calculation*



**Figure 4. Movement of VN-Index and money supply (M2) of foreign countries**

*Source: Author's calculation*



**Figure 5. Correlation Matrix**

*Source: Author's calculation*

## Appendix 2. Tables

**Table 1. Summary of variables**

Variable	Description	Source
return_vnindex	Return of the Vietnam VN-Index	HOSE
cpi_eu	Consumer Price Index of the European Union	World Bank
cpi_singapore	Consumer Price Index of Singapore	World Bank
cpi_china	Consumer Price Index of China	World Bank
cpi_usa	Consumer Price Index of the United States	World Bank
fx_eu	Exchange rate of the Euro against other currencies (EUR/VND)	World Bank
fx_singapore	Exchange rate of the Singapore Dollar (SGD/VND)	World Bank
fx_china	Exchange rate of the Chinese Yuan (CNY/VND)	World Bank
fx_usa	Exchange rate of the US Dollar (USD/VND)	World Bank
interest_eu	Interest rate of the European Union	World Bank
interest_singapore	Interest rate of Singapore	World Bank
interest_china	Interest rate of China	World Bank
interest_usa	Interest rate of the United States	Federal
m2_eu	M2 Money Supply of the European Union	World Bank
m2_singapore	M2 Money Supply of Singapore	World Bank
m2_china	M2 Money Supply of China	World Bank
m2_usa	M2 Money Supply of the United States	World Bank

*Source: Author's synthesis*

**Table 2. Descriptive statistics**

	Obs	Mean	$\sigma$ (std)	Min	Max
<b>return_vnindex</b>	282	0.0099	0.0913	-0.3434	0.3852
<b>interest_us</b>	282	0.0166	0.0180	0.0005	0.0598
<b>interest_eu</b>	282	0.0286	0.0156	-0.0009	0.0532
<b>interest_china</b>	282	0.0305	0.0035	0.0000	0.0414
<b>interest_singapore</b>	282	0.0130	0.0104	0.0000	0.0420
<b>fx_us</b>	282	0.0020	0.0084	-0.0414	0.0708
<b>fx_eu</b>	282	0.0029	0.0279	-0.0857	0.1340
<b>fx_china</b>	282	0.0034	0.0315	-0.0873	0.1345
<b>fx_singapore</b>	282	0.0030	0.0171	-0.0792	0.0883

<b>cpi_us</b>	282	0.0254	0.0181	-0.0196	0.0899
<b>cpi_eu</b>	282	0.0216	0.0188	-0.0062	0.1062
<b>cpi_china</b>	282	0.0213	0.0195	-0.0179	0.0880
<b>cpi_singapore</b>	282	0.0190	0.0226	-0.0160	0.0757
<b>m2_us</b>	282	0.0052	0.0064	-0.0117	0.0640
<b>m2_eu</b>	282	0.0045	0.0036	-0.0045	0.0241
<b>m2_china</b>	282	0.0112	0.0106	-0.0127	0.0633
<b>m2_singapore</b>	282	0.0122	0.0198	-0.0207	0.1453

*Source: Author's calculation from RStudio software*

**Table 3. Transfer entropy calculation results between markets sorted by country receiving information**

<b>From</b>	<b>To</b>	<b>Transfer entropy</b>	<b>Sig</b>
interest_us	return_vnindex	0,0209	*
cpi_us	return_vnindex	0,0130	**
m2_china	return_vnindex	0,0100	**
fx_china	return_vnindex	0,0098	
fx_eu	return_vnindex	0,0077	
fx_us	return_vnindex	0,0055	.
cpi_china	return_vnindex	0,0046	*
m2_eu	return_vnindex	0,0027	
m2_singapore	return_vnindex	0,0024	.
cpi_singapore	return_vnindex	0,0015	
fx_singapore	return_vnindex	0,0014	
interest_eu	return_vnindex	0,0000	
interest_china	return_vnindex	0,0000	
interest_singapore	return_vnindex	0,0000	
cpi_eu	return_vnindex	0,0000	
m2_us	return_vnindex	0,0000	
<b>p-values: &lt; 0.001 '***', &lt; 0.01 '**', &lt; 0.05 '*', &lt; 0.1 '.'</b>			

*Source: Author's calculation from RStudio software*

**Table 4. Transfer entropy calculation results between markets sorted by country of information transmission**

<b>from</b>	<b>to</b>	<b>Transfer entropy</b>	<b>sig</b>
return_vnindex	cpi_singapore	0,0112	
return_vnindex	m2_singapore	0,0025	
return_vnindex	fx_singapore	0,0013	.
return_vnindex	cpi_china	0,0011	
return_vnindex	m2_eu	0,0005	
return_vnindex	fx_us	0,0000	



return_vnindex	fx_china	0,0000
return_vnindex	fx_eu	0,0000
return_vnindex	m2_china	0,0000
return_vnindex	cpi_us	0,0000
return_vnindex	interest_us	0,0000
return_vnindex	interest_eu	0,0000
return_vnindex	interest_china	0,0000
return_vnindex	interest_singapore	0,0000
return_vnindex	cpi_eu	0,0000
return_vnindex	m2_us	0,0000
<b>p-values: &lt; 0.001 '***', &lt; 0.01 '**', &lt; 0.05 '*', &lt; 0.1 '.'</b>		

*Source: Author's calculation from RStudio software*

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