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RESEARCH ON NONLINEAR DEPENDENCE STRUCTURES AND RISK SPILLOVERS BETWEEN THE VIETNAMESE STOCK MARKET AND INTERNATIONAL STOCK, GOLD, AND ENERGY MARKETS

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SUMMARY OF THE DOCTORAL DISSERTATION IN ECONOMICS

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SUMMARY OF THE DOCTORAL DISSERTATION

The dissertation investigates the nonlinear dependence structure and risk spillover mechanisms between the Vietnamese stock market and six international stock markets, the international gold market, and the international crude oil market over the 2015-2025 period, which is divided into the pre-COVID-19, COVID-19, and post-COVID-19 subperiods. The research gap lies in the absence of an analytical framework that simultaneously assesses pairwise dependence under extreme market conditions and system-wide connectedness. The dissertation employs GJR-GARCH models combined with conditional copulas for individual market pairs and the Diebold-Yilmaz spillover index estimated using nine 95% VaR series for the entire system. The results show that the dependence structure is nonlinear, heterogeneous, and changes across subperiods; tail dependence increased markedly during COVID-19 and was highest for the VNIndex-TWII and VNIndex-KOSPI pairs. The Total Connectedness Index increased steadily from 39.89% to 48.52% and 53.01%, while the net spillover position of the VNIndex shifted from −28.85 to +16.37 and +2.20. All three hypotheses, GT1-GT3, in the copula branch and all four hypotheses, H1-H4, in the Diebold-Yilmaz branch are supported. The findings provide evidence for cross-market risk monitoring, early warning, and state-dependent portfolio management.

Keywords: conditional copula, nonlinear dependence structure, Diebold-Yilmaz spillover index, risk spillovers, tail dependence, Vietnamese stock market.

CHAPTER 1. INTRODUCTION

1.1. Rationale for the Research Topic

As Vietnam has become increasingly integrated into the global financial system, its interconnectedness with that system has continued to grow, creating both growth momentum and new risks.

The 2015-2025 period witnessed the interaction of several major shocks, including the COVID-19 pandemic, the energy crisis, and the global monetary tightening cycle, allowing risks to spread rapidly across markets and creating an urgent need to measure the linkages between the Vietnamese stock market and international markets.

Within the global financial system, gold serves both as a store of value and as a portfolio risk management instrument, and may act as a hedge, a diversifier, or a safe-haven asset depending on market conditions. Alongside gold, crude oil is an important macroeconomic variable that affects production costs, inflation, and growth expectations, thereby directly influencing corporate profitability and indirectly affecting the stock market. In Vietnam, empirical evidence on the relationship between oil prices and the stock market remains inconclusive.

Financial globalization and advances in information technology have substantially increased interconnectedness among markets, allowing a shock in one market to spread rapidly to others. Theoretical and empirical evidence indicates that the relationships among stock, gold, and oil markets are not merely linear but are also characterized by nonlinearity, asymmetry, and market-state dependence; linkages are generally weak under normal conditions but strengthen considerably when markets come under stress.

For the Vietnamese stock market, the need for research is even more pressing because it remains an emerging market with limitations in information transparency, market depth, investor composition, and hedging instruments. Meanwhile, most previous studies have primarily employed linear measures or examined individual market pairs separately, and therefore have not simultaneously captured pairwise dependence structures under extreme conditions and

connectedness at the system-wide level. This is the research gap addressed by the dissertation.

1.2. Research Objectives

1.2.1. General Objective

The general objective of the dissertation is to investigate the nonlinear dependence structure and risk spillover mechanisms between the Vietnamese stock market and international stock, gold, and energy markets over the 2015-2025 period by combining conditional copula models with the Diebold-Yilmaz (DY) risk spillover index, thereby providing empirical evidence as a basis for proposing policy implications and investment strategies to improve the effectiveness of risk management in the context of financial integration.

1.2.2. Specific Objectives

To achieve the general objective, the dissertation pursues three specific objectives: (1) to analyze and quantify nonlinear dependence structures, tail dependence, and symmetric or asymmetric dependence between the Vietnamese stock market and each international stock, gold, and energy market using GJR-GARCH models combined with conditional copulas, while also examining changes in the dependence structure across subperiods; (2) to measure connectedness and risk spillovers across the entire market system over the 2015-2025 period using the Diebold-Yilmaz spillover index, thereby identifying total spillovers, transmission and reception directions, and the net risk-transmitting or net risk-receiving position of each market, with comparisons across the pre-COVID-19, COVID-19, and post-COVID-19 periods; and (3) to propose policy implications, risk management implications, and investment recommendations based on the empirical results obtained from the two methods.

1.3. Research Questions

Research Question 1: Is the dependence structure between the Vietnamese stock market and each international stock market, the international gold market, and the international energy market nonlinear, characterized by tail dependence, and symmetric or asymmetric; and how does it change across the three research periods?

Research Question 2: How are connectedness and risk spillovers manifested within the system comprising the Vietnamese stock market, international stock markets, and international gold and energy markets over the 2015-2025 period; and which markets act as net risk transmitters and which act as net risk receivers?

Research Question 3: What policy implications, risk management implications, and investment recommendations can be proposed based on the results of the dependence structure and risk spillover analyses?

1.4. Research Subject and Scope

The research subject of the dissertation is the nonlinear dependence structure and risk spillover mechanisms between the Vietnamese stock market and international stock markets, the international gold market, and the international energy market. The Vietnamese stock market is represented by the VNIndex. The international stock markets examined are the United States (S&P 500), China (SSEC), Japan (Nikkei 225), South Korea (KOSPI), Taiwan (TWII), and Singapore (STI). The international gold market is represented by the XAU gold price, while the international energy market is represented by the WTI crude oil price.

Research scope:

- Spatial scope: the dissertation examines the response of the Vietnamese stock market to movements in six international stock markets, namely the S&P 500, SSEC, Nikkei 225, KOSPI, STI, and

TWII, as well as the international gold market (XAU) and the international energy market (WTI).

- Time scope: daily-frequency data from January 2015 to December 2025 are used and divided into the pre-COVID-19, COVID-19, and post-COVID-19 periods.

1.5. Research Methodology

The dissertation uses daily return data for the VNIndex, S&P 500, SSEC, Nikkei 225, KOSPI, STI, TWII, XAU, and WTI over the 2015-2025 period. The two methodological branches are implemented independently and complement each other. In the first branch, ARMA-GJR-GARCH marginal models or ARMA models with constant variance are selected according to the ARCH properties of each series and each period; standardized residuals are used to estimate conditional copulas for each VNIndex-partner pair and to quantify nonlinear dependence, tail dependence, and asymmetry. Portfolio VaR at the 90%, 95%, and 99% levels is backtested using the Kupiec POF test. In the second branch, nine separate 95% VaR series for the nine markets are processed for stationarity and entered simultaneously into a VAR(9) system to calculate GFEVD, TCI, FROM, TO, NET, and NPS. The DY branch does not use copula parameters, copula residuals, or two-asset portfolio VaR as inputs.

1.6. Contributions of the Dissertation

Upon fully achieving its research objectives, the dissertation is expected to make several novel practical and scientific contributions, as follows:

New scientific contributions:

First, the dissertation extends the approach to studying dependence structures and risk spillovers across financial markets in a nonlinear, asymmetric, and time-varying direction by applying conditional

copula models combined with GJR-GARCH. This method enables the quantification of dependence structures, tail dependence, and changes in market linkages, thereby addressing the limitations of traditional linear correlation models.

Second, the dissertation employs the Diebold-Yilmaz (DY) risk spillover index to simultaneously measure overall connectedness and the net risk-transmitting or net risk-receiving positions between the Vietnamese stock market and the entire system of international stock, gold, and energy markets, thereby clarifying the directional, heterogeneous, and time-varying characteristics of network-based risk spillover mechanisms.

Third, the dissertation uses a dataset covering the 2015-2025 period, encompassing major events such as the COVID-19 pandemic, the monetary tightening cycle, and the energy crisis, thereby providing updated empirical evidence on dependence structures and risk spillovers in the context of international financial integration.

New practical contributions:

The findings show that the VNIndex exhibits nonlinear and heterogeneous tail dependence with partner markets; asymmetry is present in several pairs and is partially supported by the empirical results. Tail dependence increased markedly during COVID-19 for many Asian stock market pairs, particularly VNIndex-TWII and VNIndex-KOSPI, but did not increase uniformly across all pairs. Overall connectedness in the DY system increased during COVID-19 and remained high after the pandemic. These findings confirm the complementary value of conditional copulas in analyzing bilateral dependence and of the Diebold-Yilmaz framework in measuring directional risk spillovers at the system-wide level.

On this basis, the dissertation proposes policy implications for strengthening systemic risk monitoring, establishing early-warning mechanisms, improving market transparency, developing hedging instruments, and supporting state-dependent portfolio management. At the same time, the findings also provide a scientific basis for enhancing resilience and supporting the roadmap for upgrading the Vietnamese stock market in the context of international financial integration.

From an academic perspective, the dissertation adds empirical evidence on dependence structures and risk spillovers in an emerging market and develops an integrated analytical framework combining conditional copulas and the Diebold-Yilmaz spillover index. Conditional copulas are used to quantify dependence structures and tail dependence for individual market pairs, whereas the Diebold-Yilmaz framework clarifies the intensity and direction of spillovers and the position of each market within the entire network. This combination helps address the limitations of traditional linear models and provides a more comprehensive approach to financial risk research.

CHAPTER 2. THEORETICAL FOUNDATIONS AND REVIEW OF EMPIRICAL STUDIES

2.1. Related Concepts

The stock market is where securities are issued, purchased, sold, and transferred, and it plays a role in mobilizing and allocating medium- and long-term capital for the economy (Fabozzi and Modigliani, 2009). Market performance is associated with the quality of the legal framework and the degree of investor protection (La Porta et al., 1997; Beck et al., 2003); in Vietnam, this framework is governed by the Law

on Securities (National Assembly, 2019) and its implementing regulations. In addition, foreign investment, particularly foreign portfolio investment, contributes to greater market liquidity and interconnectedness while also increasing sensitivity to external shocks (Bekaert, Harvey, and Lundblad, 2005; Ferreira and Matos, 2008).

Regarding dependence structures, market volatility reflects fluctuations in returns and is commonly measured by the standard deviation (Gregoriou, 2009). Dependence reflects the degree and form of linkages among markets through the joint distribution of returns and is not limited to linear correlation (Sklar, 1959; Joe, 1997).

Tail dependence describes the likelihood that markets move jointly under extreme conditions. Financial crises and extreme events are periods in which the degree of dependence among markets often changes markedly relative to normal conditions (Longin, 2016), while systemic risk reflects the possibility that a localized shock may spread throughout the entire system (Adrian and Brunnermeier, 2016).

2.2. Theoretical Foundations of Contagion and Transmission Channels

Contagion theory originated in medicine and sociology and was later applied in finance to describe the transmission of a shock from one market to others beyond the effects of economic fundamentals (Rigobon, 2002). This process operates through two groups of channels: real-linkage channels, including international trade, exchange rates, interest rates, and macroeconomic shocks; and financial-linkage channels, including international capital flows, the banking system, and investor behavior.

At the mechanism level, four main explanations include liquidity constraints and investors' capital constraints (Kyle and Xiong, 2001),

information asymmetry and learning from prices (King and Wadhwani, 1990), shifts among multiple equilibria driven by self-fulfilling expectations (Masson, 1998), and herding behavior when information costs are high (Calvo and Mendoza, 2000). Interdependence, which is a stable linkage based on fundamentals, must be distinguished from contagion, which is an abnormal increase in dependence during a crisis (Forbes and Rigobon, 2002).

2.3. The Roles of Gold and Oil in Financial Markets

Gold is regarded as a hedge, a diversifying asset, or a safe-haven asset depending on market conditions (Baur and Lucey, 2010; Baur and McDermott, 2010; Reboredo, 2013). In contrast, crude oil is cyclical, reflects real economic activity, and affects inflation, production costs, and growth expectations, with the magnitude of its impact depending on whether the underlying shock originates from supply or demand (Hamilton, 1983; Kilian, 2009; Filis, Degiannakis, and Floros, 2011). Therefore, the relationships among gold, oil, and the stock market should be analyzed across market states rather than represented by a fixed coefficient.

2.4. Review of Empirical Studies

The first research stream uses copulas and conditional copulas to describe nonlinear dependence and tail dependence. Patton (2006, 2012) developed the conditional copula framework for financial time series; Rodriguez (2007), Aloui et al. (2011), Hussain and Li (2018), and Mohti et al. (2019) showed that tail dependence increases markedly during periods of instability, thereby reducing diversification benefits.

The second research stream uses the Diebold-Yilmaz spillover index (2009, 2012, 2014), based on generalized forecast error variance decomposition, to measure overall connectedness, transmission and reception directions, and the net position of each market; frequency-

domain extensions (Baruník and Křehlík, 2018) and time-varying-parameter extensions (Antonakakis et al., 2020) provide additional dynamic perspectives. In addition, supporting methods such as GJR-GARCH (Glosten, Jagannathan, and Runkle, 1993), DCC-GARCH (Engle, 2002), and TVP-VAR (Primiceri, 2005) are used to characterize volatility and dynamic correlations.

2.5. Research Gap

First, previous studies have mainly used individual methods separately and lack an integrated analytical framework capable of simultaneously assessing pairwise dependence structures and spillover mechanisms at the system-wide level. Second, most studies have examined individual market pairs and have not simultaneously placed the Vietnamese stock market, international stock markets, gold, and crude oil within the same system or compared them consistently across periods. Third, studies on Vietnam and the region, such as Hung and Vo (2021), Ngo et al.

(2022), Le and Luong (2022), Nguyen et al. (2023), and Chancharat and Chancharat (2024), provide valuable evidence but have not developed an integrated research framework using the same dataset.

CHAPTER 3. RESEARCH METHODOLOGY AND DATA

Based on the theoretical and empirical foundations analyzed above, the dissertation develops two groups of hypotheses corresponding to the two methodological branches. The first group consists of three hypotheses, GT1, GT2, and GT3, for the conditional copula branch; these hypotheses are evaluated through the selection of copula families using the AIC criterion and the estimated tail-dependence coefficients:

Hypothesis GT1: The dependence structure between the Vietnamese stock market and international stock markets, the international gold

market, and the international energy market is nonlinear and heterogeneous across market pairs; therefore, it cannot be fully described by a linear correlation coefficient or a single copula family.

Hypothesis GT2: Tail dependence exists between the Vietnamese stock market and partner markets, indicating the possibility of joint movements under extreme conditions; the degree of tail dependence may be asymmetric between the lower and upper tails, with different magnitudes and directions of asymmetry across market pairs.

Hypothesis GT3: The dependence structure and degree of tail dependence between the Vietnamese stock market and partner markets differ across the pre-COVID-19, COVID-19, and post-COVID-19 periods.

The second group consists of four hypotheses, H1-H4, for the Diebold-Yilmaz (DY) risk spillover index branch, as follows:

H1(DY): Directional risk spillovers exist between the Vietnamese stock market and international stock, gold, and energy markets.

H2(DY): The system's Total Connectedness Index increases during the COVID-19 period relative to the pre-COVID-19 period.

H3(DY): The net risk-transmitting or net risk-receiving position (NET) of the Vietnamese stock market changes across the research periods.

H4(DY): The magnitude and direction of risk spillovers are heterogeneous across partner markets and change over the research periods.

Based on the research objectives and the two groups of hypotheses above, the dissertation develops research models corresponding to the two methodological branches, as follows:

Research model for the Diebold-Yilmaz (DY) spillover index: The dissertation estimates a vector autoregressive model of order p,

VAR(p), for the vector X_t comprising nine 95% VaR series (VNIndex, S&P 500, SSEC, Nikkei 225, KOSPI, STI, TWII, XAU, and WTI):

$$X_t = \sum_{i=1}^{p} \phi_i X_{t-i} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma).$$

The infinite moving-average representation is:

$$X_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i},$$

where A_i is the coefficient matrix reflecting the impact of a unit shock. Using the Generalized Forecast Error Variance Decomposition of Pesaran and Shin (1998) at an H-step-ahead forecast horizon, the contribution of a shock from market j to the forecast error variance of market i, denoted $\theta_{ij}(H)$, is normalized as $\bar{\theta}_{ij}(H)$ so that each row sums to 1.

Total Connectedness Index:

$$TCI(H) = \left[\frac{\sum_{i \neq j} \bar{\theta}_{ij}(H)}{N}\right] \times 100.$$

Spillovers received by market i from all other markets:

$$FROM_i = \left[\frac{\sum_{j \neq i} \bar{\theta}_{ij}(H)}{N}\right] \times 100.$$

Spillovers transmitted by market i to all other markets:

$$TO_i = \left[\frac{\sum_{j \neq i} \bar{\theta}_{ji}(H)}{N}\right] \times 100.$$

Net spillover position:

$$NET_i = TO_i - FROM_i.$$

$NET_i > 0$ indicates that market i is a net risk transmitter; $NET_i < 0$ indicates that market i is a net risk receiver.

Conditional copula approach: In the dissertation, the dependence structure between the Vietnamese stock market (VNIndex) and each international stock market is modeled using a conditional copula function. For each market pair, let $r_{VN,t}$ denote the VNIndex return and $r_{j,t}$ denote the return of international stock market j, where j represents the S&P 500, SSEC, Nikkei 225, KOSPI, STI, and TWII, respectively. Let $F_{VN}(\cdot|\Omega_{t-1})$ and $F_j(\cdot|\Omega_{t-1})$ be the conditional marginal distribution functions of the two return series, where Ω_{t-1} is the information set available at time t−1. Then:

$$u_t = F_{VN}\left(r_{VN,t} \mid \Omega_{t-1}\right), \qquad v_t = F_j\left(r_{j,t} \mid \Omega_{t-1}\right).$$

According to Sklar's theorem, the conditional joint distribution of the two return series is specified as follows:

$$H_t\left(r_{VN,t}, r_{j,t} \mid \Omega_{t-1}\right) = C_t\left(u_t, v_t \mid \Omega_{t-1}; \theta_t\right),$$

where:

H_t: the conditional joint distribution function of the VNIndex return and the return of market j;

C_t: the conditional copula function describing the dependence structure between the two markets;

FVN and Fj: the conditional marginal distribution functions of the VNIndex return and the return of market j;

θ_t: the dependence parameter reflecting the degree of dependence between the two markets; it is estimated separately for each research period and may therefore differ across periods;

$\Omega t-1$: the information set available at time t−1.

The research methods are employed to achieve the research objectives as follows:

(1) Objective 1: To analyze and quantify nonlinear dependence structures, tail dependence, and symmetric or asymmetric dependence between the Vietnamese stock market and international stock, gold, and energy markets:

The dissertation employs conditional copula models with marginal distributions specified using ARMA-GJR-GARCH(1,1) models or ARMA models with constant variance, depending on the ARCH test results for each series and period. Two copula groups are considered: elliptical copulas (Gaussian and Student-t) and Archimedean copulas together with their rotated and survival variants (Clayton, Gumbel, Frank, Joe, BB1, BB6, BB7, and BB8). The models are used to quantify nonlinear dependence, tail dependence, and asymmetry

between the VNIndex and each partner market. Portfolio VaR at the 90%, 95%, and 99% confidence levels is estimated using Monte Carlo simulation and backtested using the Kupiec POF test.

(2) Objective 2: To measure connectedness and risk spillovers across the entire market system, with comparisons among the pre-COVID-19, COVID-19, and post-COVID-19 periods:

The dissertation uses the Diebold-Yilmaz (DY) risk spillover index, estimated from a VAR system simultaneously comprising nine 95% VaR series (the VNIndex and eight partner markets), to measure overall connectedness (Total Connectedness Index), spillovers received by each market (FROM), spillovers transmitted by each market (TO), and the net position (NET = TO − FROM), thereby clarifying the directional and heterogeneous risk spillover mechanisms between the Vietnamese stock market and each partner market.

(3) Objective 3: To propose policy implications, risk management implications, and investment recommendations:

The results from the conditional copula and Diebold-Yilmaz approaches are compared across the pre-COVID-19, COVID-19, and post-COVID-19 periods to clarify changes in pairwise dependence structures and risk spillover positions across the entire system. Based on the empirical results from both branches, the dissertation proposes implications for regulatory authorities, investors, and financial institutions to improve the effectiveness of risk management and support the upgrading of the Vietnamese stock market.

CHAPTER 4. RESEARCH RESULTS AND DISCUSSION

The descriptive statistics and test results show that the return series are not normally distributed and are all stationary; ARCH effects are present in many series but are not homogeneous across markets and periods. Accordingly, the marginal distributions are flexibly specified using either ARMA-GJR-GARCH models or ARMA models with

constant variance. After synchronization with VNIndex trading days, the numbers of observations are 1,035 for the pre-COVID-19 period, 500 for the COVID-19 period, and 578 for the post-COVID-19 period.

Table 4.10. Estimation Results for the Elliptical Copula Family

Partner market	Copula family	par1	par2	Lower tail	Upper tail	VaR9 0%	VaR9 5%	VaR9 9%
Pre-COVID-19 period (2015-2019)								
S&P 500	F2 - t	0.108	6.222	0.046	0.046	-0.813	-1.115	-1.877
SSEC	F2 - t	0.206	7.185	0.048	0.048	-0.982	-1.355	-2.348
Nikkei 225	F2 - t	0.247	7.134	0.057	0.057	-0.958	-1.331	-2.318
KOSPI	F2 - t	0.222	8.597	0.034	0.034	-0.766	-1.061	-1.825
STI	F2 - t	0.195	6.503	0.057	0.057	-0.767	-1.052	-1.777
TWII	F2 - t	0.274	5.521	0.098	0.098	-0.791	-1.102	-1.935
XAU	F2 - t	-0.071	15.087	0.001	0.001	-0.694	-0.927	-1.475
WTI	F2 - t	0.053	8.966	0.014	0.014	-1.457	-1.955	-3.049
COVID-19 period (2020-2022)								
S&P 500	F2 - t	0.094	8.823	0.017	0.017	-1.345	-1.942	-3.760
SSEC	F2 - t	0.257	6.543	0.070	0.070	-1.167	-1.721	-3.536
Nikkei 225	F2 - t	0.240	5.312	0.095	0.095	-1.349	-1.962	-3.928
KOSPI	F2 - t	0.287	4.226	0.147	0.147	-1.326	-1.935	-3.908
STI	F2 - t	0.219	5.613	0.081	0.081	-1.041	-1.558	-3.290
TWII	F2 - t	0.277	3.368	0.185	0.185	-1.261	-1.862	-3.843
XAU	F2 - t	-0.023	14.239	0.001	0.001	-1.000	-1.458	-2.970
WTI	F2 - t	-0.010	11.060	0.004	0.004	-2.009	-2.797	-4.837
Post-COVID-19 period (2023-2025)								
S&P 500	F2 - t	0.081	5.280	0.058	0.058	-0.986	-1.408	-2.603
SSEC	F2 - t	0.153	7.495	0.035	0.035	-0.978	-1.405	-2.650
Nikkei 225	F2 - t	0.205	6.342	0.062	0.062	-1.157	-1.631	-2.944
KOSPI	F2 - t	0.218	6.261	0.066	0.066	-1.159	-1.648	-3.049
STI	F2 - t	0.145	6.161	0.053	0.053	-0.826	-1.202	-2.345
TWII	F2 - t	0.204	5.940	0.070	0.070	-1.165	-1.655	-2.996
XAU	F1 - Gauss	-0.055	0.000	0.000	0.000	-0.933	-1.292	-2.275
WTI	F2 - t	-0.053	9.687	0.006	0.006	-1.288	-1.767	-2.983

Table 4.12. Estimation Results for the Archimedean Copula-GJR-GARCH Model

Partner market	Copula family	par1	par2	Lower tail	Upper tail	VaR90 %	VaR95 %	VaR99 %
Pre-COVID-19 period (2015-2019)								
S&P 500	F19 - SBB7	1.084	0.097	0.105	0.001	-0.833	-1.138	-1.918
SSEC	F9 - BB7	1.103	0.219	0.042	0.126	-1.001	-1.387	-2.415
Nikkei 225	F9 - BB7	1.131	0.251	0.063	0.155	-0.973	-1.360	-2.385
KOSPI	F19 - SBB7	1.126	0.195	0.149	0.029	-0.765	-1.059	-1.857
STI	F9 - BB7	1.075	0.246	0.060	0.094	-0.791	-1.091	-1.859
TWII	F9 - BB7	1.188	0.246	0.059	0.208	-0.806	-1.123	-1.965
XAU	F26 - RJoe90	-1.069	0.000	0.000	0.000	-0.701	-0.930	-1.449
WTI	F4 - Gumbel	1.043	0.000	0.000	0.056	-1.474	-1.962	-2.996
COVID-19 period (2020-2022)								
S&P 500	F19 - SBB7	1.066	0.121	0.084	0.003	-1.376	-1.979	-3.833
SSEC	F9 - BB7	1.164	0.239	0.055	0.186	-1.186	-1.754	-3.612
Nikkei 225	F19 - SBB7	1.184	0.193	0.204	0.027	-1.367	-1.996	-4.086
KOSPI	F9 - BB7	1.123	0.340	0.130	0.147	-1.372	-2.012	-4.081
STI	F9 - BB7	1.094	0.262	0.071	0.115	-1.070	-1.608	-3.402
TWII	F9 - BB7	1.183	0.303	0.102	0.203	-1.326	-1.952	-3.985
XAU	F26 - RJoe90	-1.046	0.000	0.000	0.000	-1.003	-1.446	-2.883
WTI	F16 - SJoe	1.039	0.000	0.051	0.000	-2.064	-2.874	-4.989

Partner market	Copula family	par1	par2	Lower tail	Upper tail	VaR90%	VaR95%	VaR99%
Post-COVID-19 period (2023-2025)								
S&P 500	F14 - SGumbel	1.057	0.000	0.073	0.000	-1.015	-1.437	-2.613
SSEC	F14 - SGumbel	1.106	0.000	0.129	0.000	-0.989	-1.427	-2.731
Nikkei 225	F9 - BB7	1.184	0.130	0.005	0.205	-1.178	-1.647	-2.917
KOSPI	F19 - SBB7	1.071	0.264	0.090	0.072	-1.168	-1.639	-2.991
STI	F19 - SBB7	1.080	0.167	0.100	0.016	-0.841	-1.216	-2.366
TWII	F19 - SBB7	1.114	0.218	0.137	0.042	-1.181	-1.668	-3.032
XAU	F5 - Frank	-0.295	0.000	0.000	0.000	-0.934	-1.298	-2.297
WTI	F23 - RClay90	-0.101	0.000	0.000	0.000	-1.295	-1.758	-2.903

Source: Author's estimation and calculations.

The conditional copula results show that the dependence structures between the VNIndex and partner markets are nonlinear, exhibit tail dependence, and are heterogeneous across market pairs and periods. Within the elliptical group, the pre-COVID-19 correlation coefficient

ρ for stock-market pairs ranges from 0.1081 to 0.2739; XAU has ρ = -0.0705 and WTI has ρ = 0.0525. During COVID-19, tail dependence increases markedly for many Asian stock-market pairs, most notably VNIndex-TWII (λL = λU = 0.1848) and VNIndex-KOSPI (λL = λU = 0.1469). The Archimedean results reveal different forms of tail asymmetry across pairs; for example, during COVID-19, VNIndex-Nikkei 225 has λL = 0.2040, exceeding λU = 0.0273. After COVID-19, VNIndex-XAU is described by a Gaussian copula or a Frank copula with zero tail dependence, indicating conditional diversification potential rather than evidence of immunity or an absolute safe-haven property.

When assessed against the hypotheses of the conditional copula branch, all three hypotheses are supported by the empirical results. GT1 is supported because the Student-t copula is selected in 23 of the 24 combinations in the elliptical group, with the post-COVID-19 VNIndex-XAU pair as the sole case using the Gaussian copula, whereas the Archimedean group selects multiple families, including BB7, Survival BB7, Gumbel, Survival Gumbel, Survival Joe, Frank, and

Rotated Clayton 90 degrees. The AIC comparison shows that the elliptical specification has a lower AIC in 10 of 24 combinations, or approximately 42%; therefore, no single copula family can describe all market pairs and periods.

GT2 is supported because tail-dependence coefficients are positive for all stock-market pairs, ranging from 0.0174 for the S&P 500 during COVID-19 to 0.1848 for TWII during COVID-19, while those for XAU and WTI are close to zero. The Archimedean group shows that λL differs from λU for many pairs; for example, pre-COVID-19 SSEC

has λL = 0.042 versus λU = 0.126, while Nikkei 225 during COVID-19 has λL = 0.204 versus λU = 0.027.

GT3 is supported because the tail-dependence coefficients for the VNIndex-TWII pair are 0.0983, 0.1848, and 0.0697 across the three periods, respectively, while those for VNIndex-KOSPI are 0.0339, 0.1469, and 0.0662. In addition, the optimal copula families for many pairs change across periods, with VNIndex-XAU shifting from Rotated Joe 90 degrees to Frank.

Table 4.13. Results of VaR Backtesting Using the Kupiec POF Test

Copula group	Period	No. of tests	Passed	Failed	Failed cases
Elliptical	Pre-COVID-19	24	23	1	VNIndex-STI; VaR 90%; p = 0.0435
Elliptical	COVID-19	24	24	0	-
Elliptical	Post-COVID-19	24	24	0	-
Archimedean	Pre-COVID-19	24	23	1	VNIndex-STI; VaR 90%; p = 0.0435
Archimedean	COVID-19	24	24	0	-
Archimedean	Post-COVID-19	24	24	0	-
Total	Three periods	144	142	2	The two cases stated above

Source: Author's estimation and calculations.

Note: The 142 of 144 tests that pass (98.61%) confirm the adequacy of the violation rate for portfolio VaR in the copula branch; this result is not used as a substitute for backtesting the nine market VaR series in the DY branch.

4.3. RESULTS OF THE DIEBOLD-YILMAZ SPILLOVER INDEX (DY)

The Diebold-Yilmaz index is estimated independently from a VAR(9) system comprising nine separate 95% VaR series for the VNIndex, S&P 500, SSEC, Nikkei 225,

KOSPI, STI, TWII, XAU, and WTI. The TCI increases from 39.89% before COVID-19 to 48.52% during COVID-19, an increase of 8.63 percentage points. After COVID-19, it reaches 53.01%, which is 13.12 percentage points higher than before the pandemic and 4.49

percentage points higher than during the pandemic. The results show that system connectedness increased during the crisis and remained at a high level after COVID-19.

Summary of Key Diebold-Yilmaz Indicators for the VNIndex and the Overall System

Indicator	Pre-COVID-19	COVID-19	Post-COVID-19
VNIndex own-variance share (diagonal)	56.85	34.30	30.90
FROM of the VNIndex	43.15	65.70	69.10
TO of the VNIndex	14.29	82.07	71.31
NET of the VNIndex (TO - FROM)	-28.85	+16.37	+2.20
System-wide TCI	39.89	48.52	53.01

Source: Author's compilation from the Diebold-Yilmaz results in Tables 4.15-4.17.

Net Spillover Positions (NET) of the Markets Across the Three Periods

Market	Pre-COVID-19	COVID-19	Post-COVID-19
VNIndex	-28.85	+16.37	+2.20
S&P 500	-2.86	+15.56	+32.77
SSEC	-28.66	-6.95	-9.48
Nikkei 225	-43.30	+11.77	+10.91
KOSPI	+39.01	+10.39	+4.19
STI	+25.43	-43.46	-19.24
TWII	+55.89	+21.26	+30.67
XAU	-1.37	-18.18	-51.71
WTI	-15.29	-6.76	-0.32

Source: Author's estimation and calculations.

The VNIndex shifts from a net risk-receiving position before COVID-19 (NET = -28.85) to a net risk-transmitting position during COVID-19 (NET = +16.37) and continues to be a net transmitter at a lower intensity after COVID-19 (NET = +2.20). TWII maintains a strong net-transmitting position, ranking first in the system before and during COVID-19 (NET = +55.89 and +21.26); after COVID-19, the S&P 500 has the highest NET (+32.77), followed by TWII (+30.67). XAU

Net Pairwise Spillovers (NPS) between the VNIndex and Each Partner Market

Partner market	Pre-COVID-19	COVID-19	Post-COVID-19
S&P 500	**-5.05**	**+10.07**	**-6.32**

SSEC	**+0.68**	**+2.92**	**+1.47**
Nikkei 225	**+2.69**	**-3.13**	**-3.39**
KOSPI	**-8.00**	**-3.11**	**-1.34**
STI	**-7.20**	**+10.01**	**+3.08**
TWII	**-12.81**	**-3.45**	**-4.78**
XAU	**+0.13**	**+2.78**	**+13.86**
WTI	**+0.72**	**+0.28**	**-0.37**

Note: NPS > 0 indicates that the VNIndex is a net risk transmitter to the partner market; NPS < 0 indicates that the VNIndex is a net risk receiver from the partner market.

Source: Author's calculations based on the DY matrices in Tables 4.15-4.17.

During the COVID-19 period, Nikkei 225, KOSPI and TWII jointly contribute 60.93 percentage points to the FROM of the VNIndex, equivalent to about 92.7% of its total FROM, while the VNIndex transmits 51.24 percentage points to these three markets, equivalent to about 62.4% of its total TO. After COVID-19, the spillover from XAU to the VNIndex equals 0.00, whereas the spillover from the VNIndex to XAU equals 13.86, indicating a one-directional spillover within the DY matrix; this is not sufficient to conclude that gold is entirely immune to shocks or an absolute safe-haven asset.

4.4. DISCUSSION OF THE RESEARCH RESULTS

The empirical results from the two independent branches complement each other. The conditional copula branch shows that the dependence structure between the VNIndex and partner markets is nonlinear, exhibits tail dependence, varies across sub-periods and displays asymmetric tail dependence for several market pairs, with the direction and magnitude of asymmetry differing across pairs. All three hypotheses GT1, GT2 and GT3 of this branch are supported by the empirical evidence. For the Diebold-Yilmaz branch, all four hypotheses H1 to H4 are likewise supported: directional spillovers exist; the TCI increases during COVID-19 relative to the pre-COVID-19 period; the NET position of the VNIndex changes across sub-

periods; and the NPS differs across partner markets and over time. All conclusions are interpreted in terms of contributions to forecast error variance decomposition rather than causal relationships.

CHAPTER 5. CONCLUSIONS AND POLICY IMPLICATIONS

5.1. Conclusions on the Main Research Results

The dissertation has accomplished its general objective and its three specific objectives. The conditional copula approach clarifies the nonlinear dependence structure, tail dependence, asymmetry and the variation across sub-periods between the VNIndex and each partner market, thereby supporting all three hypotheses GT1, GT2 and GT3; 142 of the 144 Kupiec POF tests for portfolio VaR in the copula branch pass, equivalent to 98.61%. Independently of the copula branch, the Diebold-Yilmaz approach clarifies the connectedness and directional spillovers of the system of nine market VaR series and supports all four hypotheses H1 to H4: the TCI rises from 39.89% to 48.52% and 53.01%, while the NET of the VNIndex changes from -28.85 to +16.37 and +2.20. The comparison across the three sub-periods shows that both the dependence structure and the spillover position vary with market conditions; on this basis, the dissertation proposes implications for regulators, investors and financial institutions.

With respect to the research results, the dissertation obtains the following main findings:

(1) The dependence structure between the VNIndex and partner markets is nonlinear, heterogeneous and time-varying, consistent with all three hypotheses GT1, GT2 and GT3. Tail dependence increases markedly during COVID-19 for many Asian stock market pairs, most notably VNIndex-TWII with $\lambda = 0.1848$ and VNIndex-KOSPI with $\lambda = 0.1469$, although the increase is not uniform across all pairs. Asymmetric tail dependence is documented for several pairs within

the Archimedean family. In addition, 142 of the 144 Kupiec POF tests for portfolio VaR in the copula branch pass, equivalent to 98.61%.

(2) The TCI increases by 8.63 percentage points during COVID-19 relative to the pre-COVID-19 period and rises by a further 4.49 percentage points after COVID-19. The own-variance share on the diagonal of the VNIndex declines from 56.85% to 34.30% and 30.90%, while the NET shifts from -28.85 to +16.37 and +2.20. These results reflect an increase in systemic connectedness, but they are not interpreted directly as causal evidence or as an absolute decline in market autonomy.

(3) The magnitude and direction of spillovers are heterogeneous across partner markets. During COVID-19, Nikkei 225, KOSPI and TWII contribute 60.93 percentage points to the FROM of the VNIndex, equivalent to about 92.7% of its total FROM, while the VNIndex transmits 51.24 percentage points to these three markets, equivalent to about 62.4% of its total TO. After COVID-19, the spillover from XAU to the VNIndex equals 0.00 whereas the spillover from the VNIndex to XAU equals 13.86, indicating a one-directional spillover within the DY matrix. TWII records the highest NET before and during COVID-19, whereas the S&P 500 records the highest NET after COVID-19.

The combination of the conditional copula and Diebold-Yilmaz approaches establishes a unified analytical framework that simultaneously identifies bivariate dependence structures under extreme market conditions and system-wide risk spillover positions. Overall, the dissertation confirms that financial integration both increases the connectedness and the risk-receiving exposure of the Vietnamese stock market and raises the likelihood that this market becomes a source of risk spillovers within the region, which provides

important empirical grounds for research on financial stability and risk management in Vietnam.

5.2. Policy Implications

Based on the research results, the dissertation proposes groups of policy implications for regulators, investors and financial institutions. For regulators, supervision should shift from single-market monitoring toward monitoring systemic risk and cross-market risk transmission in both directions, and indicators of tail dependence, the total connectedness index and the NET position of each market should be incorporated into the early warning system. In addition, the market upgrading process should be linked to the capacity to control the risk spillovers that the Vietnamese market may generate for the region, in line with the orientations set out in Decision No. 1726/QD-TTg and the Scheme for Upgrading the Vietnamese Stock Market (Decision No. 2014/QD-TTg).

For investors and financial institutions, asset allocation should move from an approach based on average correlation toward portfolio management based on tail dependence and system-wide spillover positions. The finding of low tail dependence between the VNIndex and XAU suggests a potential for conditional diversification and hedging through gold; nevertheless, allocation strategies must still be assessed period by period and should not assume that gold is always an absolute safe-haven asset. Movements in WTI should be monitored as a source of both market risk and cost risk. Firms, securities companies and financial institutions should develop energy price scenarios, improve the quality of information disclosure and integrate cross-market data into their internal risk management systems.

LIST OF PUBLISHED WORKS RELATED TO THE DISSERTATION

Domestic journals:

Dang Thi Phuong Thao & Phan Thi Hang Nga. (2026). Nonlinear Spillover Effects between Gold and Oil Prices in Vietnamese and Global Markets: A Quantile-on-Quantile Approach. *Journal of Finance - Marketing Research.*

International journals:

Dang Thi Phuong Thao, Hoang Thai Hung, & Phan Thi Hang Nga. (2025). Dependence structure of the Vietnam stock market on the international stock market. *Ianna Journal of Interdisciplinary Studies*, 7(2), 211-222.

Le Thi Thuy Van, Dang Thi Phuong Thao, & Phan Thi Hang Nga. (2025). The nonlinear dependence of the Vietnam stock market on the Asian stock market: Evidence from a quantile-on-quantile regression. *International Journal of Innovative Research and Scientific Studies*.

Dang Thi Phuong Thao, & Buhong Liu. (2026). The spillover effects of gold and oil prices: A study of the Vietnamese and global markets. *Journal of Financial Economic Policy*.