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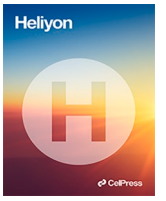

Research article

Return spillover of Vietnam's sectors in response to US uncertainties

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ABSTRACT

This paper investigates the impact of US economic policy uncertainty and geopolitical risk on the return spillovers among 24 sectors in Vietnam from April 13, 2017, to April 8, 2022. The VAR-based connectedness approach and quantile techniques are employed in this study. Empirical results from the study reveal that an increase in US economic policy uncertainty significantly impacts return spillovers. However, this impact is only observed during periods of heightened uncertainty in US economic policy. Economic policy uncertainty plays a more prominent role in affecting the spillovers across Vietnamese sectors compared to geopolitical risk. Findings from our analysis also highlight the crucial role of the banking sector as a transmitter of risk in the Vietnamese stock market.

1. Introduction

As the global financial market has become more interconnected, domestic financial markets are increasingly vulnerable to external shocks. These shocks can arise from various sources, such as global recessions, monetary and trade policies, diseases, natural disasters, or geopolitical risks. They have the potential to disrupt the spillover structure and lead to unexpected fluctuations in the financial system, thus undermining public confidence and threatening financial stability [1]. Therefore, it is crucial to examine the impact of external shocks on domestic stock markets to ensure financial market's stability and attract capital flows.

Vietnam has emerged as one of the world's fastest-growing economies [2], garnering significant attention and investment from both domestic and international investors. Fig. 1 depicts the total number of trading accounts in Vietnam's stock market from 2017 to 2023. Notably, there was a 17 % increase in the total number of trading accounts in 2020 compared to the previous year. This growth accelerated to 56 % in 2021 and further surged to 60 % in 2022, indicating strong investor interest in the Vietnamese stock market. These statistics emphasize the rising importance and appeal of the Vietnamese stock market for potential investors. Yet, it is worth mentioning that Vietnam is one of the Asian countries with the largest trade openness [3]. This characteristic of Vietnam's economy could potentially increase the susceptibility of its stock market to external shocks. On the other hand, the Vietnamese stock market in particular and Asia-Pacific stock markets in general are known to have a strong dependence on the US economy since the 2008 global recession, which makes them susceptible to US shocks [4,5]. Against this backdrop, the study aims to examine the impact of US shocks, including economic policy uncertainty and geopolitical risk, on Vietnam's stock market, as well as the response of the Vietnamese sectors under different market conditions caused by US economic policy uncertainty. This is particularly relevant in the current global

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landscape, which is heavily influenced by the Russo-Ukrainian conflict [6].

This study contributes to the existing literature in several ways. First, the extant literature mainly focuses on the impact of economic policy uncertainty on the Vietnamese stock market's sectoral spillovers. The impact of geopolitical risk has largely been ignored, although geopolitical risk is one of the most important drivers of investment decisions [6]. As such, this study examines the impact of geopolitical risk and economic policy uncertainty on inter-sectoral return spillovers in Vietnam. Second, the extant literature has already provided evidence of the effect of US economic policy uncertainty on sectoral spillover in Vietnam. However, the asymmetric property of this effect during periods of low, medium, and high uncertainty has been underexamined. Third, we extend the scope of our study by examining the effects from 24 sectors instead of solely focusing on the 14 main sectors examined in the previous study. Following this introduction, the rest of the paper is organized as follows. Section 2 presents a literature review. Section 3 presents the methodology and data used in the study. Empirical findings are presented and discussed in section 4, followed by the concluding remarks and implications in section 5.

2. Literature review

The extant literature mainly focuses on the spillovers among sectors rather than the drivers of sectoral spillovers. For example, Chen et al. [7] conducted a study on sectoral returns and volatility spillovers in the Shanghai-Shenzhen-Hong Kong Stock Markets from June 2011 to December 2020. The authors observed that the spillover effects primarily occurred in the short term. Specifically, they found that the Hang Seng public utilities, telecommunications, and real estate construction sectors acted as risk absorbers, while the Shanghai material, energy, and industrial sectors acted as risk transmitters. In another investigation, Laborda and Olmo [8] employ a VAR-based connectedness approach to measure risk transmission across seven economic sectors in the United States. They identified that the main channels for shocks to propagate throughout the economy were banking and insurance, energy, technology, and biotechnology sectors. During the COVID-19 crisis, the energy and technology sectors were particularly influential, while the banking and insurance sectors played a significant role during the global financial crisis of 2007 and 2009.

Economic policy uncertainty (EPU) refers to uncertainties arising from anticipated government economic policies and regulations [9], while geopolitical risk (GPR) encompasses uncertainties related to war, terrorism, and geopolitical tensions [10]. Numerous studies have documented that uncertainties caused by the EPU and GPR exert detrimental effects on economic activity and, therefore, adversely affect the stock market in particular [10,11] and the financial market in general [12,13]. However, the extant literature mainly focuses on their impacts on the specific stock market performance, while the investigation of the impact of these two uncertainties on sectoral spillovers within a stock market is still scarce. For example, Jiang et al. [14] found that GPR has a long-term negative impact on tourism stock returns in China, with a greater impact at lower quantiles. Similarly, Tran and Vo [6] investigated the effects of various uncertainties on market returns and volatility in the Asia-Pacific region. Their findings suggest that US uncertainty indices, such as US geopolitical risk, US economic policy uncertainty, and US VIX, significantly impact Pacific stock markets. However, local political risk and the US skewness index have minimal impacts. The study highlights the greater influence of US economic policy uncertainty than US geopolitical risk.

In the strand of the impact of the EPU on sectoral spillovers within stock market, Dang et al. [15] employ ordinary least squares (OLS) regression with Newey and West [16] standard errors to investigate the effects of the COVID-19 pandemic proxied by new infection cases and the containment and health index, economic policy uncertainty (EPU), and macroeconomic fundamentals proxied by the exchange rate and interbank rate on sectoral volatility spillover. Their findings suggest that an increase in daily new infections leads to greater intersectoral connectivity. Additionally, reducing economic policy uncertainty appears to lower intersectoral volatility spillovers in the Vietnamese stock market. However, it is important to acknowledge that Dang et al. [15] and the extant literature have not addressed three specific issues. First, no previous studies examined the impact of geopolitical risk on intersectoral volatility spillovers in the stock market in general and the Vietnamese stock market in particular. Second, in contrast to Dang et al. [15], our

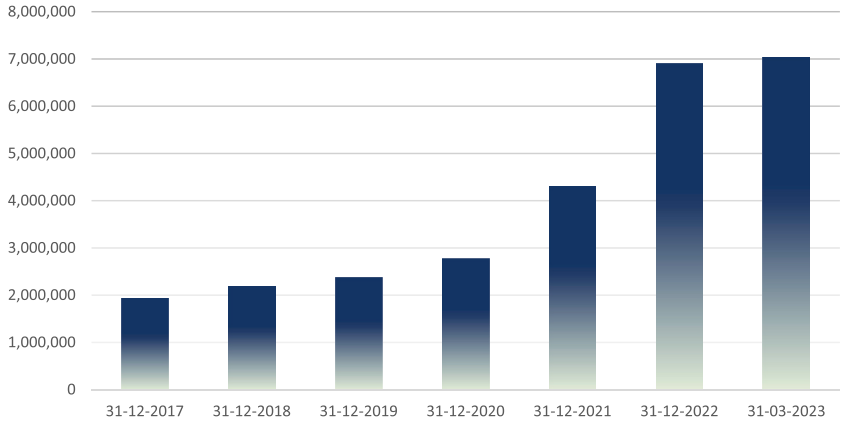

Fig. 1. The number of stock trading accounts in Vietnam, 2017–2023.
Source: Vietnam Securities Depository Center

analysis takes into account spillover effects across a broader range of sectors. We consider a total of 24 sectors, rather than solely focusing on 14 main sectors used in the aforementioned study. Last but not least, no studies have paid attention to the response of inter-sectoral return spillovers under different market conditions caused by US economic policy uncertainty. Such an investigation is crucial as it provides investors and policymakers with specific strategies in different market conditions. Motivated by these research gaps, our study is warranted to be conducted to provide additional and meaningful policy implications.

3. Data and methodology

3.1. Data

This study focuses on the sectoral return spillover effects in the Vietnamese stock market using the daily closing prices of 24 sectoral indices. The sample period spans from the April 13, 2017 until April 8, 2022. The sectoral returns are estimated as follows:

$$R_t^i = \ln\left(\frac{P_t^i}{P_{t-1}^i}\right)$$

Where P_t^i denotes the closing price of the sectoral index i at day t, and R_t^i is the return on the sectoral index i at day t.

Additionally, we also investigate the factors that contribute to intersectoral connectedness. These factors are (i). Geopolitical risks are measured using the geopolitical risk (GPR) index proposed by Caldara and Iacoviello [10]; (ii). US economic policy uncertainty (EPU), measured using the index proposed by Baker et al. [11]; and (iii). Vietnamese gold return. The US is Vietnam's largest export market [17]. On the other hand, trade plays a significant role in transmitting external shocks to the domestic stock market [18,19]. As such, the Vietnamese stock market is expected to be influenced by US shocks. This study investigates the impact of shocks originating from the United States on the Vietnamese sectoral market. To measure US geopolitical risk, the study utilizes a global GPR index instead of a US GPR index due to the unavailability of country-level GPR indices in daily frequency. The global GPR index is derived from US-based newspapers such as the Chicago Tribune, Los Angeles Times, The New York Times, USA Today, The Wall Street Journal, and The Washington Post. As such, the index construction based on these newspapers allows the global GPR index to serve as a suitable proxy of the US GPR index effectively. This argument is further strengthened through correlation analysis, which demonstrates a remarkably high Pearson correlation coefficient (98.95 %) between the global GPR index.[1] and the US GPR index.

In this study, a set of control variables for macroeconomic fundamentals are also considered, including the exchange rate and the three-month interbank rate. Table 1 provides a detailed description of each variable along with its data source. Table 2 presents the descriptive statistics for the variables employed in the study. Our sample includes around 1000 observations, with the returns varying across sectors. Furthermore, the last column indicates that all the variables are stationary.

3.2. Methodology

3.2.1. Estimating the sectoral return spillovers

To investigate the transmission of a return across different sectors in the Vietnamese stock market. The VAR-based connectedness approach proposed by Diebold and Yilmaz [20,21] is employed. This approach allows for a thorough exploration of the association's structure, including the direction of transmission, the intensity of spillovers, and the scale of the effects.

Diebold and Yilmaz [20] present the spillover metrics based on variance decomposition from vector autoregressions (VARs) that track how much of the future error variance of a variable j is attributed to innovations in another variable k. To calculate total volatility spillovers for N assets, we consider an N-dimensional vector of realized volatility, RVt = (RV_{1t}, …, RV_{Nt}). We now utilize a weakly stationary VAR(p) to represent the N-dimensional vector RVt as $RVt = \Sigma_{l=1}^{p}\varphi_l RV_{t-l} + \varepsilon_t$, where $\varepsilon_t \sim N(0, \Sigma_\varepsilon)$ is a vector of *iid* disturbances, and φ_l stands for p coefficient matrices. The moving average expression for the invertible VAR function is as follows:

$$RV_t = \sum_{l=0}^{\infty}\psi_l\varepsilon_{t-l}$$

The N x N matrices with coefficients ψ_l are constructed using the recursion $\psi_l = \Sigma_{j=1}^{p}\varphi_j\psi_{l-j}$, where $\psi_0 = I_N$ and $\psi_l = 0$ for $l < 0$. The moving average representation is useful for expressing the dynamics of the VAR system, given that it enables us to separate the forecast mistakes, which are then utilized to compute the system's connectedness. Diebold and Yilmaz [21] extend the generalized VAR of Koop, Pesaran, and Potter [22] and Pesaran and Shin [23] to generate forecast error variance decompositions that are unaltered to variable ordering in the VAR model, along with explicitly enabling the measurement of directional volatility spillovers. The generalized VAR allows the correlated shocks. As such, the shocks to each variable are not orthogonalized.

To calculate the total spillovers index of Diebold and Yilmaz [24], we examine the H-step-ahead generalized forecast error variance decomposition matrix, which has the following elements for H = 1, 2, …

[1] To ensure comparability with the US GPR index when conducting correlation analysis, the global GPR index is transformed into a monthly frequency by taking the average.

Table 1
The variables used in this study and their data sources.

Variables	Definition	Sources
Sectoral indices	Daily 24 sectoral indices on Vietnam's stock market	Datastream via Eikon
Geopolitical risk index	Daily global geopolitical risk index	matteoiacoviello.com
Economic policy uncertainty	Daily US Economic Policy Uncertainty Index	FRED economic data
FX return	Daily Return of Vietnamese dong per US dollar	Datastream via Eikon
Interbank rate	Daily three-month interbank rate, % per year	Datastream via Eikon
Gold return	Daily Vietnamese gold return	Datastream via Eikon

Table 2
The descriptive statistics.

Variables	Obs.	Mean	Std. Dev	Min	Max	Unit-root test
Real Estate	1247	0.001	0.014	−0.071	0.059	−34.171***
Rubber	1247	0.0005	0.015	−0.068	0.051	−31.836***
Securities	1247	0.001	0.020	−0.079	0.070	−32.256***
Technology	1247	0.001	0.016	−0.100	0.068	−39.455***
Oil&Gas	1247	0.001	0.020	−0.081	0.065	−33.899***
Services	1247	0.001	0.025	−0.120	0.159	−38.186***
Development Investment	1247	0.0004	0.019	−0.200	0.099	−34.859***
Construction Investment	1247	0.001	0.019	−0.082	0.075	−42.812***
Pharmaceutical	1247	0.001	0.011	−0.056	0.057	−30.767***
Public Service	1247	0.001	0.017	−0.068	0.286	−37.211***
Education	1247	0.0004	0.022	−0.078	0.088	−39.701***
Aviation	1247	0.0005	0.016	−0.096	0.093	−33.341***
Mineral	1247	0.001	0.024	−0.221	0.149	−37.182***
Energy	1247	0.0004	0.011	−0.063	0.047	−33.997***
Banking	1247	0.001	0.020	−0.122	0.096	−41.241***
Plastic	1247	0.0002	0.012	−0.065	0.051	−33.845***
Fertilizer	1247	0.001	0.017	−0.066	0.063	−34.129***
Business	1247	0.001	0.015	−0.100	0.184	−37.199***
Steel	1247	0.001	0.019	−0.075	0.065	−35.284***
Food	1247	0.000	0.013	−0.089	0.071	−36.841***
Trade	1247	0.001	0.018	−0.142	0.082	−37.560***
Aquaculture	1247	0.001	0.019	−0.105	0.088	−36.275***
Transportation	1247	0.001	0.014	−0.069	0.064	−37.450***
Building Materials	1247	0.001	0.018	−0.076	0.063	−35.088***
GPR	1160	107.790	60.856	9.492	539.583	−15.441***
EPU	1160	149.722	112.773	10.920	807.660	−10.655***
Interbank rate	1160	3.059	1.313	1.180	5.320	−1.390*
FX return	1159	0.001	0.087	−0.608	0.785	−31.733***
Gold return	1133	0.028	0.923	−5.901	6.343	−33.710***

Note: ***Obs*** is the number of observations, while ***Std.Dev*** is Standard Deviation. ***GPR*** is the global geopolitical risk index. ***EPU*** is the US economic policy uncertainty index. ***FX return*** represents the return of Vietnamese dong per US dollar. ***The interest rate*** is the three-month interbank interest rate. Augmented Dickey–Fuller (ADF) is employed for testing the null hypothesis of the unit root. * and *** are significance levels at 10 % and 1 %, respectively.

$$\theta_{jk}^{H} = \frac{\sigma_{kk}^{-1}\Sigma_{h=0}^{H-1}\left(e_j'\psi_h\Sigma_\varepsilon e_h\right)^2}{\Sigma_{h=0}^{H-1}\left(e_i\cdot\psi_h\Sigma_\varepsilon\psi_h' e_k\right)}$$

j, k = 1, …, N

where ψ_h are moving average coefficients from the forecast at time t; Σ_ε stands for the variance matrix for the error vector, ε_t; σ_{kk} is the kth diagonal element of Σ_ε; e_j and e_k are the selection vectors, where one represents the jth or kth element and zero otherwise. The row sums as $\widetilde{\theta}_{jk}^{H} = \theta_{jk}^{H}/\Sigma_{k=1}^{N}\theta_{jk}^{H}$ are used to normalize elements. The total connectedness is then defined by Diebold and Yilmaz [24] as the contribution of connectedness from volatility shocks across variables in the system to the total forecast error variance:

$$TSI = 100\times\frac{1}{N}\sum_{j,k=1,j\neq k}^{N}\widetilde{\theta}_{jk}^{H}$$

$\Sigma_{k=1}^{N}\widetilde{\theta}_{jk}^{H} = 1$ and $\Sigma_{j,k=1}^{N}\widetilde{\theta}_{jk}^{H} = \mathrm{N}$.

As a result, the contributions of connectedness from volatility shocks have been normalized by the total forecast error variance.

This study investigates the spillover effects of return using a VAR (Vector Autoregression) model with a lag length of 4. The forecast

variance error is computed for a 10-day-ahead period, and rolling-sample windows of 200 days are used. The lag length is determined based on Akaike's information criterion (AIC). Additionally, a robustness test is conducted in the study to assess the sensitivity of the results to these parameters. This is achieved by varying the VAR lag orders (1 lag, 2 lags, 3 lags, 4 lags), forecast horizons (5 days, 10 days, 15 days), and rolling-sample window lengths (150 days, 200 days, 250 days). By conducting these variations, the study seeks to ensure the robustness and reliability of the findings.

3.2.2. The determinants of the sectoral return spillover in the Vietnamese stock market

In addition to analyzing the sectoral return spillover effects, this study also examines the factors contributing to the return spillover among 24 sectors in the Vietnamese stock market. The model used in our analysis is as follows:

$$TSI_t = \alpha_0 + \beta_1 GPR_t + \beta_2 EPU_t + \beta_3 Interbank_t + \beta_4 FX_t + \beta_5 Gold_t + \varepsilon_t \quad (1)$$

Where TSI_t represents the total return spillover index at day t. GPR_t is the geopolitical risk index at day t. EPU_t is the US economic policy uncertainty index on day t, $Interbank_t$ is the three-month interbank interest rate at day t, FX_t is the return of Vietnamese dong per US dollar on day t, $Gold_t$ is the Vietnamese gold return on day t and ε_t is the residual.

The interbank rate is included in our model because a higher interbank rate leads to an increase in lending rates. This, in turn, raises the cost of capital for firms and potentially reduces the cash flow available for future dividend payments. This effect is particularly significant for the securities and real estate sectors, the two largest sectors in the Vietnamese stock market. In situations where the interbank rate is high, capital may flow to other sectors less affected by the high interbank rate, leading to increased spillovers at the aggregate sector level. However, it is worth noting that a higher interbank rate also makes equity investments less attractive, causing investors to become hesitant about investing in the stock market [25]. This hesitation may, in turn, reduce spillovers at the aggregate sector level. We also consider the trade-off from the investors when investing in the stock market by considering the exchange rate return and gold return, given that gold and forex are two common investments in Vietnam.

Furthermore, the study employs a quantile technique to examine the response of spillovers at different levels of economic policy uncertainty (EPU). This approach provides comprehensive information on how the impact of EPU on spillovers varies during low, medium, and high periods of US economic policy uncertainty. The following models are utilized:

$$TSI_t = \alpha_0 + \beta_1 GPR_t + \beta_2 EPU_t + \beta_3 Interbank_t + \beta_4 FX_t + \beta_5 Gold_t + \varepsilon_t \text{ if } -\infty < Q_{TSI|EPU}(\tau) \leq \text{Q1} \quad (2)$$

$$TSI_t = \alpha_0 + \beta_1 GPR_t + \beta_2 EPU_t + \beta_3 Interbank_t + \beta_4 FX_t + \beta_5 Gold_t + \varepsilon_t \text{ if Q1} < Q_{TSI|EPU}(\tau) \leq \text{Q3} \quad (3)$$

$$TSI_t = \alpha_0 + \beta_1 GPR_t + \beta_2 EPU_t + \beta_3 Interbank_t + \beta_4 FX_t + \beta_5 Gold_t + \varepsilon_t \text{ if Q3} < Q_{TSI|EPU}(\tau) \leq +\infty \quad (4)$$

Where $-\infty < Q_{TSI|EPU}(\tau) \leq$ Q1 is when the EPU distribution is in lower quantiles, or it is a period of low EPU level; Q1 $< Q_{TSI|EPU}(\tau) \leq$ Q3 is when the EPU distribution is in middle quantiles, or it is period of normal EPU level; Q3 $< Q_{TSI|EPU}(\tau) \leq +\infty$ is when the EPU distribution is in upper quantiles, or it is period of high EPU level. The other denotations are the same as those of Eq. (1). Both the White test (for testing heteroskedasticity) and the Durbin-Watson test (for testing autocorrelation) in Table 3 reject the null hypothesis at the significance level of 1 %, indicating heteroskedasticity and autocorrelation in our model. As such, Eqs. (1)–(4) are estimated using the Newey and West [16] estimator, which are robust to autocorrelation and heteroskedasticity.

4. The empirical results

4.1. The sectoral return spillover in Vietnam's stock market

This section presents the findings of static evidence of the spillover effects among the 24 sectors in the Vietnam stock market during the investigation period from 2017 to 2022. The Vector Autoregression (VAR)-based connectedness approach by Diebold and Yilmaz [21] is utilized for the analysis, and the empirical results are presented in Table 4. Column "TO" presents the spillovers from a sector to the other sectors. In contrast, column "FROM" presents the spillovers from the other sectors to a sector. NET denotes the difference between "TO" and "FROM", representing whether a sector is a net transmitter or a net receiver. A positive value indicates that a sector is a net transmitter, whereas a negative value indicates a sector is a net receiver. The Total Spillover Index (TSI) is the average spillover effect among the 24 sectors in the Vietnamese stock market. The TSI for all sectors in Vietnam is determined to be 69.71 %, indicating

Table 3
Testing the presence of autocorrelation and heteroskedasticity.

	White test	Durbin-Watson test
Chi^2 statistic	380.32	28508.782
P value	0.000	0.000

Note: The White test is employed to test the null hypothesis of homoscedasticity, while the Durbin-Watson test is employed to test the null hypothesis of no serial correlation. The White test is conducted on STATA using command "estat imtest, white" while the Durbin-Watson test is performed using "estat durbinalt".

Table 4
The return spillover effect among 24 sectors in the Vietnamese stock market for the period 2017–2022.

Sector	TO	FROM	NET
Real Estate	55.51	70.71	−15.2
Rubber	54.47	67.38	−12.91
Securities	101.18	81.70	19.47
Technology	91.25	77.56	13.7
Oil & Gas	85.59	79.23	6.36
Services	34.93	52.06	−17.13
Development Investment	66.73	69.87	−3.14
Construction Investment	52.72	65.25	−12.52
Pharmaceutical	58.87	70.89	−12.02
Public Service	20.85	40.57	−19.72
Education	9.63	27.88	−18.25
Aviation	51.56	68.22	−16.66
Mineral	52.18	64.91	−12.73
Energy	59.35	68.76	−9.42
Banking	117.46	80.07	37.39
Plastic	73.51	76.32	−2.81
Fertilizer	61.07	72.04	−10.97
Business	91.86	76.43	15.43
Steel	93.1	80.16	12.94
Food	81.25	74.81	6.44
Trade	94.92	77.94	16.98
Aquaculture	70.92	72.66	−1.74
Transportation	91.86	76.20	15.66
Building Materials	102.29	81.44	20.85
Total Spillover Index (TSI)	**69.71 %**		

substantial spillover effects across these sectors.

Table 4 also indicates that the "NET" values highlight the most significant risk transmitters within the market. Banking, Building Materials, and Securities sectors exhibit the highest "NET" values of 37.39 %, 20.85 %, and 19.47 %, respectively. This implies that these sectors play a crucial role as major sources of risk transmission in the Vietnamese stock market. Consequently, when significant market returns arise in these sectors, they quickly spread to other sectors. On the other hand, the Public Service, Education, and Service sectors are identified as the most significant risk absorbers, as they possess the lowest "NET" values of −19.72 %, −18.25 %, and −17.13 %, respectively.

Furthermore, we also investigate the sectoral return transmission patterns before and after the COVID-19 pandemic. To this end, we

Table 5
The sectoral return spillover effect **before** and **during** the COVID-19 pandemic.

	Before COVID-19			During COVID-19		
	TO	FROM	NET	TO	FROM	NET
Real Estate	44.46	61.53	−17.08	73.24	82.61	−9.37
Rubber	42.5	56.37	−13.86	73.75	82.76	−9.01
Securities	96.19	77.4	18.79	97.47	85.48	11.99
Technology	86.36	71.95	14.41	103.56	85.05	18.51
Oil & Gas	80.97	75.28	5.69	85.5	84.42	1.08
Services	27.79	41.6	−13.81	44.68	70.72	−26.04
Development Investment	49.04	57.3	−8.26	102.58	85.31	17.26
Construction Investment	42.39	51.99	−9.6	52.89	73.18	−20.28
Pharmaceutical	50.21	59.17	−8.96	62	78.49	−16.49
Public Service	16.48	28.36	−11.88	29.24	63.51	−34.26
Education	8.48	21.72	−13.24	10.87	38.06	−27.19
Aviation	54.35	65.49	−11.14	46.2	75.85	−29.65
Mineral	43.1	54.11	−11	64.48	76.53	−12.05
Energy	41.4	55.68	−14.28	84.06	83.93	0.13
Banking	124.17	78.37	45.79	107.54	84.19	23.35
Plastic	63.02	70.09	−7.07	90.19	85.37	4.82
Fertilizer	55.22	66.01	−10.79	65.9	78.99	−13.09
Business	70.65	66.94	3.71	122.89	87.35	35.53
Steel	91.49	75.8	15.69	91.72	84.9	6.82
Food	75.89	68.71	7.18	96.84	83.78	13.06
Trade	85.9	71.88	14.02	105.11	85.0	20.11
Aquaculture	57.88	64.55	−6.67	88.54	83.02	5.52
Transportation	77.95	68.29	9.66	108.6	85.42	23.18
Building Materials	99.92	77.2	22.72	102.21	86.14	16.07
Total spillover index	**61.91 %**	**79.59 %**				

divide the full sample into two subsamples: the periods just preceding the pandemic (from April 13, 2017, to January 22, 2020) and the periods following the pandemic (from January 23, 2020, to April 8, 2022). The results of this analysis are presented in Table 5. Before the COVID-19 pandemic, the sectors of Banking, Building Materials, and Securities (with the highest "NET" values of 45.79 %, 22.72 %, and 18.79 %, respectively) played a critical role as the most significant risk transmitters across the Vietnamese stock market. However, during the COVID-19 pandemic, the most substantial risk transmitters were Business, Banking, and Transportation, with the highest "NET" values of 35.53 %, 23.35 %, and 23.18 %, respectively. These findings highlight that Banking consistently acts as a significant risk transmitter to other sectors before and after the pandemic. On the other hand, in the period preceding the COVID-19 pandemic, the sectors of Real Estate, Energy, and Rubber are identified as the three most significant risk absorbers, with the lowest "NET" values of −17.08 %, −14.28 %, and −13.86 %, respectively. However, during COVID-19, the three largest risk absorbers were Public Service, Aviation, and Education, with the lowest "NET" values of −34.26 %, −29.65 %, and −27.19 %, respectively. Overall, this indicates that the COVID-19 period witnessed significantly stronger sector-to-sector return transmission compared to the period before the pandemic. The total spillover index (TSI) also increased after the pandemic (79.59 %) in comparison to the TSI before the pandemic (61.91 %). The Development Investment, Plastic, and Aquaculture sectors also transitioned from being risk absorbers to risk transmitters following the COVID-19 pandemic. This suggests that these three sectors were more vulnerable to the impacts of the COVID-19 pandemic compared to other sectors in Vietnam.

The results presented in Tables 4 and 5 focus solely on the overall inter-sector total return spillover throughout the analyzed period, disregarding any changes in the spillover indices over time. Therefore, we investigated the variation in sectoral return spillover from 2017 to 2022, as shown in Fig. 2. This plot illustrates the fluctuation of the sectoral return spillover index over time, ranging from 47.07 % in 2019 to 88.05 % in 2020. These findings indicate that the extent of return transmission among sectors in the system varies. This could be attributed to various factors, such as financial emergencies, epidemiological crises like COVID-19, and conflicts like the Russian-Ukrainian war. The return transmission among markets experienced a significant increase following the North Korea-United States Hanoi Summit in 2019. In 2021, this return transmission intensified due to the onset of the fourth COVID-19 outbreak, which also happens to be the most severe outbreak in Vietnam since the pandemic emerged in January 2020.

Moving on to Fig. 3, it illustrates the net pairwise directional return connectedness network for each Vietnamese sector. This figure reveals the direction and strength of return connectivity between sectors. The arrows indicate the transmission direction of the net pairwise connection between sectors, while the nodes represent the sectors within the Vietnamese stock market. The blue cells in this scheme represent the return spillover transmitters for these sectors, while the yellow nodes represent the sectors receiving the return spillover within the system. The node size corresponds to the weighted average net total directional connectedness, while the thickness of the edges indicates the degree of the net pairwise connection across sectors. The findings from Fig. 3 confirm that the net pairwise return connection between sectors such as Real Estate - Transportation, Technology - Aviation, and Mineral - Banking is stronger than the net pairwise return connection between other Vietnamese sectors.

4.2. *The determinants of sectoral return spillover in the Vietnamese stock market*

In this section, we examine the influence of the dynamics of US economic policy uncertainty (EPU) and geopolitical risk on sectoral return spillovers in the Vietnamese stock market. We utilized the Newey-West estimators for this analysis, which are robust to heteroskedasticity and autocorrelation, as indicated in Table 3. The results are presented in Table 6, whose Columns (1) and (2) consider the impact of GPR and EPU, respectively, on sectoral spillovers, while Column (3) considers both of them. Our findings indicate that the US economic policy uncertainty has significantly affected return spillovers among Vietnamese sectors. Evidence for the impact of GPR cannot be established in this study. The findings align with Pietro and Luboš [26] 's signal precision theory, which suggests that market volatility is influenced by the combination of political uncertainty and signal precision. According to this theory, uncertainty signals generated by government policies originate from a recognized formal institution. On the other hand, signals resulting from infrequent occurrences like terrorist attacks or wars randomly enter the market, making them potentially difficult for investors to perceive. As such, the market tends to be affected by the EPU rather than the GPR.

Additionally, our study delves into how sectoral return spillovers respond during periods characterized by low, medium, and high US economic policy uncertainty levels. This analysis is conducted using the quantile technique to construct three market conditions: a

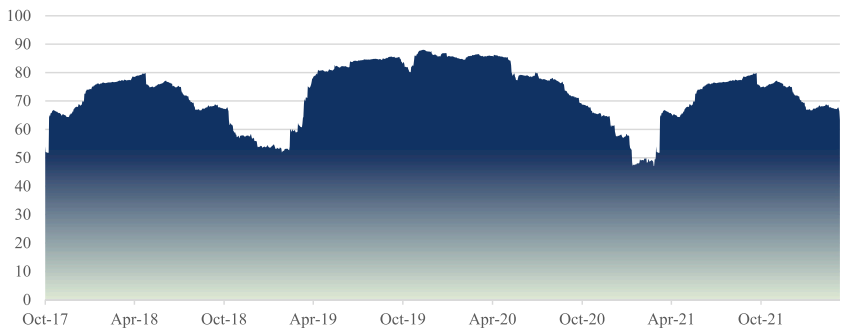

Fig. 2. The total spillover effect of all sectors over the 2017–2022 period.

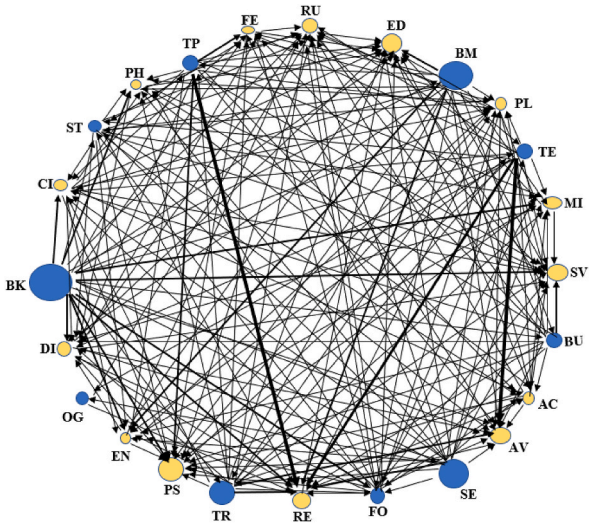

Fig. 3. The Vietnamese sectoral return spillover for the period 2017–2022.
Notes: The sectors are Real Estate (RE), Rubber (RU), Securities (SE), Technology (TE), Oil & Gas (OG), Services (SV), Development Investment (DI), Construction Investment (CI), Pharmaceutical (PH), Public Service (PS), Education (ED), Aviation (AV), Mineral (MI), Energy (EN), Banking (BK), Plastic (PL), Fertilizer (FE), Business (BU), Steel (ST), Food (FO), Trade (TR), Aquaculture (AC), Transportation (TP), Building Materials (BM).

Table 6
The determinants of sectoral return spillover in Vietnam.

Dependent variable: Total Spillover index			
Independent variables	**(1)**	**(2)**	**(3)**
EPU	0.018***		0.018***
	(0.003)		(0.003)
GPR		−0.006	−0.002
		(0.004)	(0.005)
Interest rate	0.758**	0.278	0.755**
	(0.371)	(0.357)	(0.372)
Gold return	0.264	0.358	0.270
	(0.301)	(0.333)	(0.302)
FX return	2.255	2.443	2.325
	(2.229)	(2.862)	(2.235)
Constant	67.754***	72.569***	67.995***
	(1.273)	(1.252)	(1.472)

Note: ** and *** are significance levels at 5 % and 1 %, respectively.

Table 7
The determinants of sectoral return spillover across Vietnamese sectors at different periods of US economic policy uncertainty (GPR).

Dependent variable: Total Spillover index			
Independent variables	**Periods of low EPU**	**Period of normal EPU**	**Periods of high EPU**
EPU	−0.035	−0.024	0.042***
	(0.032)	(0.031)	(0.004)
GPR	0.007	−0.005	0.002
	(0.011)	(0.008)	(0.005)
Interest rate	−1.822***	0.863	1.264*
	(0.465)	(0.540)	(0.749)
Gold return	−0.062	0.810	0.097
	(0.782)	(0.637)	(0.363)
FX return	3.934	2.087	−0.776
	(3.976)	(3.651)	(3.236)
Constant	80.983***	73.229***	58.165***
	(3.033)	(4.102)	(1.860)

Note: *, ** and *** are significant at 10, 5 and 1 %, respectively.

period of low, normal, and high US EPU corresponding to three quantile intervals (lower, mean, and upper distributions). The results are presented in Table 7, which shows that the effects vary asymmetrically across quantiles that correspond to different market conditions. The findings suggest that the impact of US economic policy uncertainty on return spillovers among Vietnamese sectors varies depending on the level of US economic policy uncertainty. Specifically, when the US economic policy uncertainty reaches a very high level, its effect on return spillovers among Vietnamese sectors becomes significant, while no significant effect is observed at low and medium levels of US economic policy uncertainty. This implies that during periods of high unpredictability in US economic policy, an increase in US economic policy uncertainty leads to an increase in spillovers across Vietnamese sectors. Conversely, this effect is not observed during periods of low and medium levels of US economic policy uncertainty.

5. A robustness analysis

To ensure the robustness of our analysis, we conducted a series of tests using various combinations of rolling windows, forecast horizons, and lag lengths. The objective of this robustness analysis was to examine the market return spillovers across 24 Vietnamese sectors. Specifically, we tested different combinations of VAR lag orders, including one lag, two lags, three lags, and four lags. Additionally, we experimented with rolling windows of 150 days, 200 days, and 250 days and forecast horizons of five days, ten days, and fifteen days. The results of this robustness analysis are displayed in Fig. 4. It is worth noting that, regardless of the specific combinations of rolling windows and forecast horizons, the overall trends and magnitudes of market return spillovers across the 24 sectors in Vietnam, as represented by the total spillover index (TSI), remained largely consistent and unchanged. This additional analysis strengthens the reliability and validity of our findings, suggesting that the observed market return spillovers among Vietnamese sectors are robust and not heavily influenced by variations in the specific combinations of rolling windows, forecast horizons, and lag lengths used in our analysis.

6. The concluding remarks and implications

The spillover effects within financial markets have always been a topic of great interest for policymakers and practitioners. Extensive research has sought to investigate market return patterns, characteristics, and spillover effects among different stock markets. Nevertheless, the study of return spillovers among various sectors within an emerging market, such as Vietnam, has been largely neglected in the existing literature. Therefore, this paper aims to fill this gap by utilizing the VAR-based connectedness approach to examine return spillovers among twenty-four sectors in the Vietnamese stock market from 2017 to 2022. Additionally, the study delves into determining whether geopolitical risk influences return spillovers and how the return spillovers react to US economic uncertainty and geopolitical risk under different market conditions.

The key empirical findings from this study can be summarized as follows: First, the transmission of sectoral return exhibits significant fluctuations over the entire investigation period. The total spillover index indicates a substantial level of sectoral connectivity in Vietnam, standing at 69.71 %, suggesting that risks spread rapidly across sectors in Vietnam's stock market. Following the emergence of the Covid-19 pandemic in 2020, the volatility spillover climbed to 88 %. Second, throughout the research period, the Banking, Building Materials, and Securities sectors are identified as the primary sources of risk transmission. Conversely, the Public Service, Education, and Service sectors are the main risk receivers during this period. Third, the study further investigates the impact of various determinants on sectoral return spillover in the Vietnamese stock market from 2017 to 2022 using the quantile technique with Newey-West standard errors and indicates that geopolitical risk has no significant effect on inter-sector return in the Vietnamese stock market in both three quantiles of EPU. In contrast, US economic policy uncertainty and the interbank rate increased sectoral volatility return spillover in the Vietnamese stock market in the high period of EPU.

Policy implications have emerged based on the findings from our study. First, our empirical results identify the Banking, Building Materials, and Securities sectors as the main risk transmitters. Following a major shock, stabilizing these sectors first is crucial for minimizing the spread of risks, as they are likely to transmit risks intensively to other sectors. Meanwhile, for the Public Service, Education, and Service sectors as the most significant risk receivers, the government should also pay more consideration to these fields, given that they are likely to absorb the most risks and become the market's most susceptible and vulnerable sectors. Portfolio managers and investors should also design suitable investment portfolios that aim to minimize risk by avoiding portfolios composed of closely associated sectors. Finally, based on the findings of factors influencing spillover effects between sectors on the Vietnamese stock market, investors and policymakers should closely monitor US economic policy uncertainty to implement appropriate measures and stabilize the market following events of economic uncertainty.

The Vietnamese stock market, as well as the Vietnamese economy, is currently undergoing a transformational process. As such, it is important for future studies to be conducted to validate and extend the findings of this study using different estimators. Additionally, considering China's pursuit of a prominent role in Asia through the Belt and Road Initiative, it is advisable for future studies to investigate the impacts of China's shocks on the Vietnamese sectors in particular and other Asian sectors in general.

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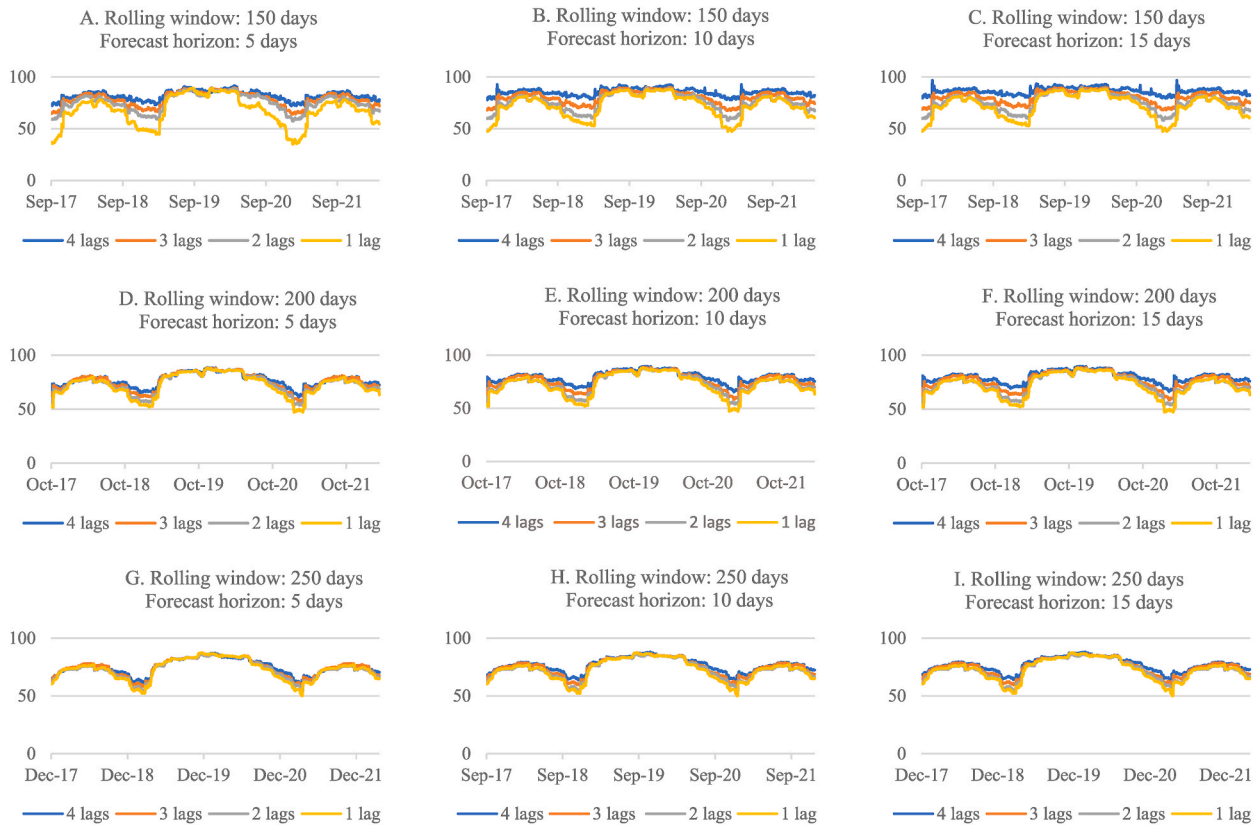

Fig. 4. Robustness test of the total return spillover index of Vietnam's stock market. Note: The blue, orange, gray, and yellow lines represent Total Spillover Index (TSI) with lag length of 4 days, 3 days, 2 days, and 1 day.

CRediT authorship contribution statement

Duc Hong Vo: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Minh Phuoc-Bao Tran:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Formal analysis, Conceptualization. **Phuong Thi-Ha Cao:** Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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