

Ripple Through the Silk Road: Analysis of Liquidity Risk Spillover Effects in Stock Markets of Belt and Road Initiative Countries

Haoyong Lu

University of Macau, Macau, 999078, China

Corresponding author: Lu Haoyong, saikashiroski@gmail.com

Abstract. As global economic policy uncertainty and geopolitical risks intensify, liquidity risk in national equity markets has risen further and shown strong interconnectedness. Based on measuring the liquidity risk of the countries along the Belt and Road, this paper applies the volatility spillover measure of Diebold and Yilmaz (2012) to analyze the spillover effects of liquidity risk in the stock markets of the countries along the Belt and Road, and puts forward some related policy recommendations.

Keywords: spillover effects, Belt and Road Initiative countries, stock markets, liquidity risk.

1. Introduction

With the advancement of the Belt and Road Initiative, the stock markets of countries along the Belt and Road are becoming increasingly interconnected. However, liquidity risk in stock markets and its contagion within the region have also become a focus of attention for investors and regulators. The factors affecting financial security are intricate and complex, and liquidity risk is often the trigger for various financial market risk events. Adequate liquidity is the basis for the stable and efficient operation of the financial market, and potential liquidity risk will threaten the financial security of the country, and will then be transmitted to the real economy, which will have a serious impact on national security [1]. Macro liquidity level of moderate abundance and financial markets local liquidity scarcity often coexist in the economic system for a long time. That is, the liquidity risk of the financial market will be affected by the overall macro liquidity conditions on the one hand, and show consistent changes in the liquidity risk of various types of assets at the micro level; however, on the other hand, due to the differences in the operating mechanism between financial markets and the differences in the product design of financial assets, the liquidity risk at the micro level will embody a strong heterogeneity. In order to better assess the liquidity risk and its spillover effect in the stock markets of the countries along the Belt and Road, this study, based on the stock market data of the countries along the Belt and Road, firstly measures the liquidity risk of each country's stock market, and then, on this basis, through the construction of the risk spillover network, measures the spillover effect of the liquidity risk of the stock markets of the countries along the Belt and Road from both the static and dynamic perspectives. The results of this study will help investors and regulators to better assess the liquidity risk and its spillover effects in the stock markets of the countries along the Belt and Road, so as to formulate more scientific and effective investment strategies and regulatory measures, and to promote the stable development of regional financial markets.

2. Literature Review

Financial market liquidity risk has always been the hot spot of academic research, but also the regulator and the industry concern, from a series of liquidity crisis evolution law can be found, liquidity risk is often generated from a local market, and quickly spread to the whole financial system. The definition of financial market liquidity can be divided into three categories: the first category is to define liquidity from the perspective of transaction costs. The second category defines liquidity from the perspective of speed. The third category defines liquidity from the perspective of the impact on price[4]. Currently, researchers have conducted extensive and in-depth studies on liquidity risk in

financial markets. Among them, some studies have focused on the measurement and quantification methods of liquidity risk, such as liquidity risk indicators, liquidity premium models, liquidity valuation models, etc. Some other studies focus on exploring the relationship between market liquidity risk and other risks, such as market risk, credit risk and operational risk. The stock market is an important research area in the study of liquidity risk [4,5]. Currently, many scholars have measured and analyzed the liquidity risk of stock markets in different countries and regions, and explored its relationship with other risks. In addition, some scholars have studied the impact of market volatility spillover effects on stock market liquidity risk and the role of liquidity risk in investor behavior and market liquidity [6,7].

3. Methodology

There are various methods of measuring volatility spillovers. Among them, the commonly used methods are VAR (Vector Autoregressive Model), GARCH (Generalized Autoregressive Conditional Heteroskedasticity Model) and DCC (Dynamic Conditional Correlation Model). In this paper, we apply Diebold and Yilmaz's (2012) volatility spillover measure to advance by measuring directional spillovers in the generalized VAR framework, which is utilized by Koop, Pesaran, and Potter (1996) and Pesaran and Shin (1998) to circumvent the problem of the results' dependence on the order of variables [9].

Define the variance share as the fraction of the h-step-ahead error variance due to shocks to x_i when predicting x_i , for $i = 1, 2, \dots, N$, the cross-covariance share or spillover effect is the fraction of the H-step error variance in forecast x_i due to shocks to x_i . As the fraction of the H-step-ahead error variance in prediction x_i due to shocks to x_i , for $i, j = 1, 2, \dots, N$, such that $i \neq j$.

Using $\theta_{ij}^g(H)$ to represent the KPPS H-step ahead forecast error variance decomposition, for $H = 1, 2, \dots$, we have:

$$\theta_{ij}^g(H) = \frac{\sigma_{ij}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}$$

Where Σ is the variance-covariance matrix of the error vector ε , σ_{jj} represents the standard deviation of the error term in the j-th equation, e_i is a selection vector with 1 as its i-th element and 0 otherwise. As previously mentioned, the sum of the elements in each row of the variance decomposition table does not equal 1:

$$\sum_{i=1}^N \theta_{ij}^g(H) \neq 1.$$

Using the volatility contributions from KPPS variance decomposition, one can construct the total volatility spillover index:

$$S^g(H) = \frac{\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_j^g(H)} \cdot 100 = \frac{\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H)}{N} \cdot 100.$$

The aggregate spillover index measures the contribution of volatility shock spillovers from asset classes to the total forecast error variance.

While studying the aggregate volatility spillover index provides insights into the shocks of volatility spillovers from major asset classes, the generalized VAR approach allows us to understand the direction of volatility spillovers from major asset classes. Since the generalized impulse response and variance decomposition are invariant with respect to the order of the variables, the directional spillovers are computed using the normalized elements of the generalized variance decomposition matrix. The directional volatility spillover received by market I from all other markets j is measured as:

$$s_i^g(H) = \frac{\sum_{j=1}^N \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{j \neq i}^N \tilde{\theta}_{ij}^g(H)}{N} \cdot 100.$$

Similarly, we measure the directional volatility spillover transmitted from market i to all other markets j as follows:

$$S_i^g(H) = \frac{\sum_{j \neq i}^N \tilde{\theta}_{ji}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ji}^g(H)} \cdot 100 = \frac{\sum_{j \neq i}^N \tilde{\theta}_{ji}^g(H)}{N} \cdot 100.$$

A set of directed overflows can be thought of as providing a decomposition of the total overflows from (or to) a particular source.

The net volatility spillover from market i to all other markets is obtained as:

$$S_i^g(H) = S_i^g(H) - S_i^g(H).$$

The net volatility spillover is simply the difference between the aggregate volatility shocks transmitted to all other markets and the aggregate volatility shocks received from all other markets.

4. Data

In this paper, the stock markets of Vietnam, China, Indonesia, New Zealand, Turkey, Thailand, Saudi Arabia, Portugal, South Africa, Romania, Qatar, South Korea, Poland, Bahrain, Palestine, Egypt, Oman, and the United States, the United Kingdom, and France, which have a large international presence, are selected as the 20 major economies along the Belt and Road.

Firstly, the logarithmic returns of stocks in 20 countries were calculated by dividing the difference between the price of the asset at the moment t minus the price of the asset at the moment $t-1$ as the rate of return, while the logarithmic difference was chosen to calculate the rate of return of the time series of the selected samples, which was calculated by the following formula:

$$R_t = (\ln P_t - \ln P_{t-1}) \times 100$$

Where P_{t-1} is the price of the asset at moment $t-1$ and P_t is the price of the asset at moment t R_t is the logarithmic return of the asset from moment $t-1$ to moment t . The logarithmic returns of stocks during the period from August 16, 2011 to July 7, 2022 are selected as the sample data, with a total of 2080 daily data.

The log stock returns for the 20 countries are shown in Figure 1. It can be found that the overall stock gains and losses in the 20 countries during the observation window under discussion are not large, with Poland's stock price in June 2020 having a more drastic time-series fluctuation of nearly 0.15. The gains and losses in the U.S. have a similar trend to those in Poland, with both declining by a large amount in June 2020, which may be related to the continued downturn of the financial markets under the epidemic. In addition, Vietnam has the smoothest trend in stock market volatility, with neither of its largest increases nor decreases exceeding 0.05.

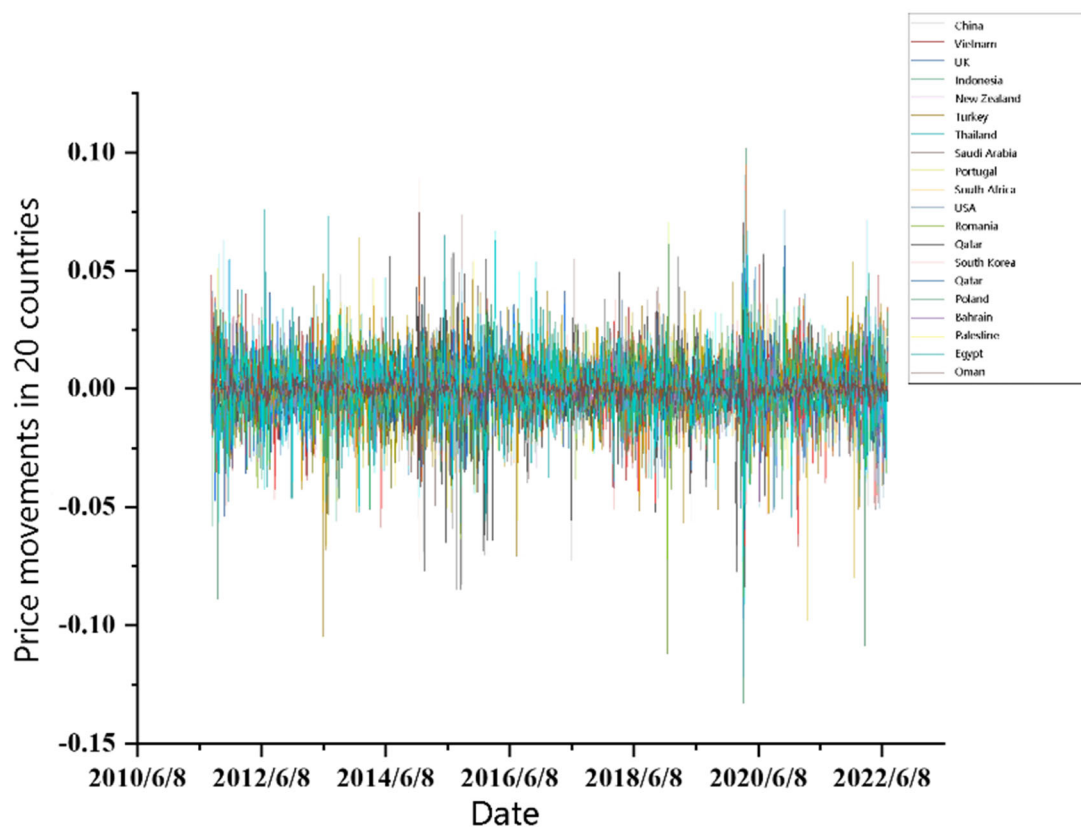


Figure 1 Interpolation of log stock returns for 20 countries

According to $r_t = (\ln p_t - \ln p_{t-1}) \times 100$, we can get the return series, and then according to the GARCH model proposed by Bollerslev (1986), we can get the volatility of the return of the corresponding financial time series, and the specific process is as follows:

$$\begin{aligned} r_t &= \mu_t + a_t \\ a_t &= \sigma_t \varepsilon_t \\ \sigma_t^2 &= \omega + \alpha \sigma_{t-1}^2 + \beta a_{t-1}^2 \end{aligned}$$

r_t is the return, μ_t is the conditional mean, a_t is the innovation, σ_t is the volatility, and ε_t is an independently identically distributed sequence (iid) with 0 mean and variance of 1. Usually, ε_t obeys the standard normal distribution, the t-distribution, the skewed t-distribution, and the generalized error distribution, and the information criterion is used to determine the specific distribution, and the volatility can be finally obtained by the GARCH (1,1) estimation of the sequence.

5. Empirical Results

5.1 Static analysis of liquidity risk spillovers

By constructing a connectivity network for liquidity risk in the stock markets of twenty countries, we obtain a spillover effect matrix, as shown in Table 1. It can be found that, from the results of the static analysis of the full sample, the net spillover effect of China is small and negative, and the spillover effect of liquidity risk with the stock markets of other countries or regions is weak. In contrast, the UK, with a net spillover index of 24.73, and France, with a net spillover index of 29.90, are more influential in the network and present a stronger risk transmission effect to other countries.

Table 1 Static spillover matrix for liquidity risk

Country	China	Vietnam	UK	Indonesia	New Zealand	Turkey	Thailand	Saudi Arabia	Portugal	South Africa	USA
China	96.66	0.02	0.12	0.02	0.04	0.03	0.06	0.16	0.03	0.14	0.83
Vietnam	0.01	84.02	0.90	1.45	0.01	0.84	0.02	0.74	0.93	1.00	0.37
UK	0.02	0.20	30.83	2.82	0.06	3.69	0.25	2.23	8.29	11.08	5.97
Indonesia	0.01	1.33	4.56	57.76	0.01	4.81	0.13	3.02	2.92	5.07	2.11
New Zealand	0.01	0.01	0.75	0.02	94.28	0.03	0.01	0.55	0.25	0.56	0.67
Turkey	0.01	1.15	6.37	5.15	0.01	55.69	0.01	1.46	2.64	4.68	2.66
Thailand	0.21	0.02	0.24	0.11	0.01	0.01	91.22	0.08	1.17	0.44	1.23
Saudi Arabia	0.03	0.66	3.73	2.72	0.47	1.45	0.16	61.12	2.47	3.33	2.31
Portugal	0.03	0.58	11.46	2.44	0.10	1.99	0.87	1.95	42.24	5.57	5.77
South Africa	0.04	0.44	14.02	3.57	0.13	3.27	0.33	2.25	5.20	37.98	5.38
USA	0.11	0.41	9.04	2.73	0.32	2.52	0.69	2.20	5.99	7.23	43.52
Romania	0.03	0.62	5.99	1.17	0.02	2.09	0.10	2.71	2.53	3.85	2.66
Qatar	0.01	1.32	2.37	3.73	0.00	3.62	0.01	4.22	1.36	3.38	1.52
South Korea	0.52	0.09	1.40	0.16	0.06	0.17	3.33	0.12	0.83	1.83	1.30
French	0.03	0.31	19.09	2.41	0.12	3.03	0.24	2.39	10.11	9.31	7.56
Polish	0.06	0.68	10.49	3.21	0.15	4.70	0.14	2.38	6.50	8.93	5.91
Bahrain	0.40	0.46	0.61	0.45	0.47	0.49	0.20	1.30	0.09	0.23	0.36
Palestine	0.55	0.10	1.00	0.84	0.02	0.87	0.29	0.46	0.73	0.58	0.17
Egypt	0.25	3.16	0.95	3.01	0.07	2.65	0.09	1.91	0.82	0.79	0.74
Oman	0.08	0.86	0.81	1.51	0.04	1.20	0.34	3.70	0.78	0.82	0.60
TO	2.39	12.40	93.90	37.52	2.12	37.47	7.28	33.81	53.63	68.81	48.11
NET	-0.95	-3.58	24.73	-4.72	-3.60	-6.84	-1.50	-5.08	-4.13	6.79	-8.38

Country	Romania	Qatar	South Korea	French	Polish	Bahrain	Palestine	Egypt	Oman	FROM
China	0.26	0.00	0.12	0.37	0.25	0.12	0.06	0.40	0.31	3.34
Vietnam	0.48	1.73	0.08	0.92	1.43	0.53	0.17	3.06	1.33	15.98
UK	2.80	1.45	0.30	19.76	8.30	0.25	0.34	0.69	0.69	69.17
Indonesia	1.30	3.22	0.09	4.32	5.10	0.35	0.33	2.34	1.22	42.24
New Zealand	0.12	0.01	0.00	1.14	1.13	0.13	0.01	0.30	0.03	5.72
Turkey	1.59	2.71	0.08	5.56	6.86	0.23	0.45	1.98	0.70	44.31
Thailand	0.36	0.01	2.99	0.63	0.33	0.22	0.25	0.10	0.40	8.78
Saudi Arabia	2.46	4.40	0.21	4.14	3.48	1.58	0.24	1.64	3.40	38.88
Portugal	1.69	1.49	0.13	14.36	7.27	0.35	0.36	0.69	0.66	57.76
South Africa	2.28	2.06	0.33	12.07	8.89	0.32	0.23	0.71	0.51	62.02
USA	2.13	1.99	0.29	11.39	7.12	0.31	0.19	1.00	0.82	56.48
Romania	61.11	3.12	0.16	6.16	5.28	0.21	0.28	0.86	1.06	38.89
Qatar	2.81	65.62	0.02	2.55	3.30	0.98	0.44	0.95	1.80	34.38
South Korea	0.64	0.03	82.69	2.26	3.70	0.10	0.48	0.22	0.09	17.31
French	2.87	1.59	0.32	29.93	8.74	0.19	0.32	0.86	0.57	70.07
Polish	3.18	2.05	0.36	11.37	37.96	0.17	0.07	1.01	0.68	62.04
Bahrain	0.44	0.39	0.02	0.29	0.57	90.11	0.80	0.60	1.72	9.89
Palestine	0.34	0.58	0.11	0.94	0.29	0.32	90.97	0.31	0.55	9.03
Egypt	0.82	1.18	0.25	1.30	1.43	1.27	0.37	77.81	1.12	22.19
Oman	0.81	1.58	0.05	0.46	0.94	2.76	0.57	1.06	81.01	18.99
TO	27.40	29.59	5.92	99.97	74.41	10.38	5.96	18.77	17.65	687.47
NET	-11.48	-4.79	-11.39	29.90	12.37	0.49	-3.07	-3.42	-1.34	34.37

5.2 Dynamic analysis of liquidity risk spillovers

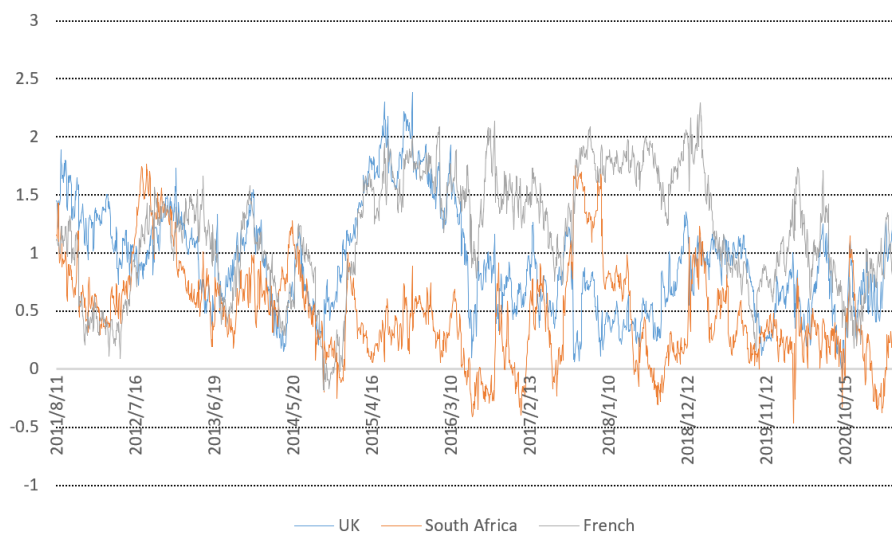


Figure 2: Dynamic Net Spillover Indices for the UK, South Africa, and France

As shown in Figure 2, the net spillovers of liquidity risk from the stock markets of three countries - the UK, South Africa and France - are positive most of the time and are net exporters of risk. London, as a traditional international financial center, attracts a large number of international investors and capital inflows. This has led to stock markets in other countries being more influenced by the UK market, resulting in positive net spillovers. During this decade, the UK experienced fluctuations in economic growth. The positive net spillovers from South Africa's stock market, the continent's economic engine, stemmed from its leadership position within the region. However, in 2016 South Africa faced poor government finances and allegations of political corruption, sparking investor concerns and negatively impacting the equity market. An overall downward trend can be seen for South Africa from 2012-2017. As a core member of the European Union, France's economy has a significant influence on the European region. Its market performance has an overall positive spillover effect on the rest of Europe.

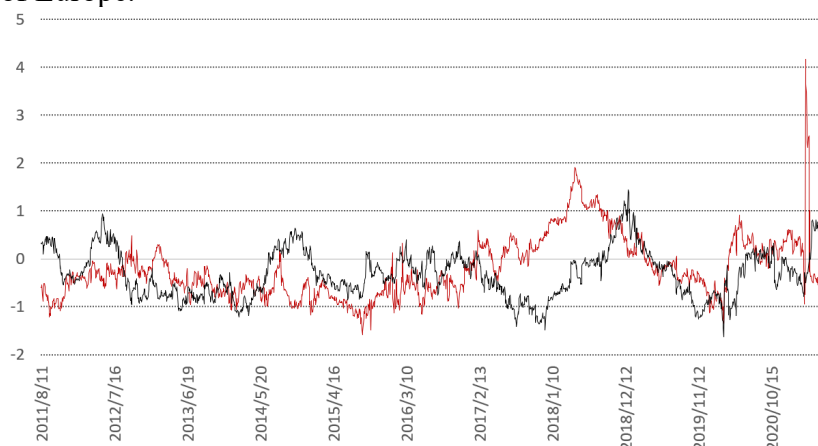


Figure 3: Dynamic Net Spillover Indices for the China and USA

In Figure 3, the dynamic net spillover indices for China and the United States are depicted, providing a nuanced illustration of the liquidity risk transmission between these two major economies. The graph reveals a complex interplay, with both countries exhibiting varying periods as net transmitters and net recipients of liquidity risk.

Throughout the observed timeline, the net spillover indices of both China and the USA demonstrate a degree of synchronicity, suggesting the presence of global economic forces or policy shifts that concurrently influence liquidity risk in both markets. This synchronous movement is punctuated by intervals of divergence, where one market's index significantly deviates from the other's, reflecting idiosyncratic market events or country-specific economic conditions that disproportionately affect one country's financial stability.

A detailed examination of the graph indicates that the Chinese market exhibits higher volatility in its net spillover index relative to the USA. This heightened volatility could be indicative of China's rapid economic development, evolving market regulation, and the growing integration of its financial markets into the global financial system. Conversely, the USA's index, while still fluctuating, displays less extreme variations, potentially alluding to the more mature and established nature of its financial markets, which may be better insulated against such volatility.

The most striking feature of Figure 3 is the pronounced spike in China's net spillover index in early 2020, soaring to nearly 5, an aberration from the overall trend. This spike is temporally aligned with the advent of the COVID-19 pandemic, which originated in China before affecting the rest of the world. The unprecedented surge in China's liquidity risk spillover during this period likely encapsulates the initial shock to the financial system as the pandemic unfolded. Market volatility during such high-impact events is expected, as investors react to uncertainty and rapidly changing economic conditions. In contrast, the USA's index does not exhibit a similar magnitude spike, which may reflect the staggered global progression of the pandemic and differing market reactions to such an exogenous shock.

The position above or below the zero line in the net spillover index graphically represents whether a country is a net exporter or importer of liquidity risk. China and the USA fluctuate around this zero line, with periods where each country's market conditions are influential enough to affect other markets (net exporter) and periods where they are more significantly influenced by external markets (net importer). This dynamism underscores the interdependent nature of global financial markets and the significant role these two nations play in the international financial architecture.

The analysis of the net spillover indices for China and the United States over this period offers invaluable insights into the liquidity risk dynamics and their transmission in the context of major economic events and crises. Particularly, the extreme value observed for China in 2020 underlines the need for robust financial mechanisms to manage and mitigate the effects of global systemic shocks, such as the COVID-19 pandemic, on financial market liquidity.

6. Conclusion

This paper explores the liquidity risk and its spillover effects in the stock markets of the countries along the Belt and Road, and reveals the significant interconnectedness of the liquidity risk of the stock markets of these countries in the face of global economic policy uncertainty and heightened geopolitical risks. By adopting the volatility spillover measure of Diebold and Yilmaz (2012), this study not only measures the liquidity risks in the stock markets of each country, but also quantifies the spillover effects of these risks from both static and dynamic perspectives by constructing risk spillover networks. The results of this study are of great significance to investors and regulators in assessing the liquidity risks and spillover effects of the stock markets of the countries along the Belt and Road, formulating more scientific and effective investment strategies and regulatory measures, and promoting the stable development of the regional financial markets.

Through our analysis, we find that the stock markets of the United Kingdom, South Africa and France generally play the role of a net exporter of liquidity risk, while the stock markets of China and the United States show a bi-directional dynamic of dominance or subordination at different times. In particular, the unusual surge in the risk spillover index of the Chinese market in the early 2020s reflects the impact of the COVID-19 epidemic on the financial markets in its early stages, as well as the significant enhancement of its risk spillover effects on a global scale.

In summary, this study validates the complex interconnectedness of global financial markets and highlights the role of member countries in the global financial system under the Belt and Road Initiative. Our findings are crucial for global financial market participants and provide a strong reference for predicting future market dynamics and formulating effective risk management strategies. In future work, it is recommended to conduct more in-depth research on the micro-mechanisms of these dynamic spillovers and to explore how liquidity risk management can be optimized through regional cooperation and macro-policy adjustments in order to enhance the resilience and stability of financial markets.

References

- [1] Qiu, L. B. (2022). Study on the Spillover Effect of RMB Exchange Rate and Stock Market Volatility Based on the Overflow Index Method (Doctoral dissertation). Yunnan University of Finance and Economics.
- [2] Zhang, K. Q., & Li, Y. B. (2022). Economic Policy Uncertainty and the Global Spillover Effect of Stock Market Volatility. *Financial Science*, 2022(07), 1-16.
- [3] Zeng, J. (2022). Analysis of the Overflow Effect of Exchange Market on Stock Market Volatility Based on Hybrid Frequency. *Cooperation, Economy, and Technology*, 2022(02), 77-79.
- [4] Chen, G. J., Zhang, R. Z., & Yao, L. L. (2014). Policy Uncertainty and the Spillover Effect of Stock Market Volatility. *Journal of Financial and Economic Research*, 29(05), 70-78+99.
- [5] Huang, Y. (2014). Research on the Overflow Effect of Stock Market and Real Estate Market Volatility. *Statistics and Decision*, 2014(02), 127-131.

- [6] Chen, G. J., Xu, D. X., & Chen, J. (2009). Analysis of the Overflow Effect of China's Stock Market and Foreign Exchange Market Volatility. *Journal of Quantitative & Technical Economics*, 26(12), 109-119.
- [7] Xie, C., Zhang, L., & Sun, B. (2012). Overflow Effect between Foreign Exchange Market and Stock Market: A Wavelet Multiscale Analysis Based on Post-Reform Data. *Journal of Systems & Management*, 21(01), 13-21.
- [8] Zhang, P. Y. (2013). Research on the Overflow Effect of China's Stock Market and Macroeconomic Volatility. *Economic Issues*, 2013(03), 46-50+68.
- [9] Diebold, F. X., & Yilmaz, K. (2012). Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers. *International Journal of Forecasting*, 28(1), 57–66.