Analysis of Asian Stock Market Spillover Effects Using Information Economy

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Abstract. The increase in uncertainty risks and complexity of the international environment have affected the normal order of the Asian economic environment and have a impact on the economic development of Asian countries. Under the general trend of information technology development, the role of information technology in visualizing economic development has also become more prominent. Stock market quotations are an important reference to reflect the real-time economic environment. The DY spillover index given in R language is used to analyze the geopolitical risks, economic policy uncertainties and spillover effects on the stock markets of major Asian economies through information integration of data, text and graphs, which is conducive to the promotion of harmonious political and economic development among Asian countries. Results showed that first, SSE Composite Index, geopolitical risk and economic policy uncertainty are the receivers of risk spillover, while Nikkei 255, Korea Composite Index and Singapore DBS Group Holdings are the transmitters of risk spillover. Second, the spillover effect between the variables is asymmetric, with significant small peaks in 2015 and 2020. Third, the total spillover effect is greater than zero, and the risk spillover effect increases significantly at the "stock market crash" in 2015 and the COVID-19 epidemic in 2020.

Keywords: DY Overflow Index · Stock Yield · EPU · GPR

1 Introduction

Since the outbreak of COVID-19 swept the world, the world has been in a panic, production and development of various countries have stagnated, and the economy has been severely hit. The game between major economies has also increasingly complicated the relations among Asian countries, which further induces systemic risks and deepens the economic risks of Asian countries. In recent years, geopolitical risk and economic policy uncertainty risk are generally considered as two important risks affecting global economic development. Since the Asian financial crisis, the economic stability of Asian countries, the financial market environment is changing rapidly, and the Asian economic environment is becoming increasingly complex. The resulting political and opinion differences with other countries have led to a significant increase in the uncertainty of China's economic policy. At the same time, a series of shocking risk events, such as the

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wide impact of china-us trade frictions and the global spread of COVID-19, have made the geopolitical environment ever-changing, and geopolitical relations among Asian countries have become increasingly tense. Under the big trend in the development of information technology, accelerate the integration of information management and economic research, through data, text, charts, information integration, is advantageous to the Asian economic visualization research and information management, at the same time, the research on geopolitical risk and uncertainty of economic policy and the major Asian economies of the spillover effect of the stock market has important political and economic significance.

ARIMA model is used for predictive analysis and it is found that COVID-19 will have a negative impact on the stock market in the short term [1]. Using the ArMA-GarCH-SKT model and R-Vine Copula model, it is found that under the impact of the epidemic, the interdependence of global stock markets presents the characteristics of asymmetric lower tail interdependence, and the collapse of stock prices brings great damage and increases the infectivity of risks in international markets [2]. Utilizing the SV-TVP-SVAR model, it is found that economic policy uncertainty has a significant time-varying impact on the linkage between commodity and stock prices in China, and further affects the hedging effect of cross-market traders' portfolios [5]. At present, DY spillover index is seldom studied in China, and it is seldom used to measure the volatility between uncertain risk and stock market in foreign countries. According to DY index, the asymmetric volatility correlation between Islamic stocks and commodity markets is studied, and it is found that there is a significant volatility correlation between Dow Jones Islamic Market Index and commodity market [4]. Applying the TVP-VAR model and DY spillover index, this paper studies the dynamic correlation between three structural oil price shocks and gold, and finds that economic policy uncertainty has a significant impact on the correlation between oil shocks and gold market [3]. The outbreak of the epidemic is bound to have a great impact on the real economy, while the virtual economy corresponding to the real economy is also hit by the spread of the real economy and the decline of investors' confidence. As an important part of the financial market, the stock market can accurately reflect the development status of the financial market. In the early stage of the outbreak, major stock markets around the world suffered panic crashes to varying degrees, but subsequently they generally continued to rise, and many stocks even hit record highs, which is difficult to explain from the perspective of the relationship between real economy and finance. To this end, this paper uses the Diebold & Yilmaz Spillover index, which is widely used in current economic research, based on the monthly percentage gains and losses of major stocks in a representative Asian economy from January 1, 2001 to November 30, 2021. Study the spillover effects of geopolitical risk and economic policy uncertainty on Asian stock markets.

Compared with the existing literature, the potential contributions of this paper lie in that firstly, the geopolitical risk, economic policy uncertainty and the major stock market quotations in Asia are incorporated into a unified framework, and the impact of uncertainty risk on the stock market is analyzed empirically, extending the research on the relationship between geopolitical risk, economic policy uncertainty and Asian economies. Secondly, based on the DY spillover effect, it analyses the spillover effect of geopolitical risk and economic policy uncertainty on the stock market of the sample economies respectively. Moreover, the stock market crash in 2015 and the COVID-19 epidemic in 2020 are considered key nodes to provide a reference for China to prevent and control the risk of economic uncertainty in the future and to further promote the joint and harmonious development of economy and politics among Asian countries.

2 Materials and Methods

2.1 Data Source

Due to data limitations, the samples in this paper cover the period from January 2001 to November 2021. The China EPU index based on the South China Morning Post constructed by Baker and Bloom et al. (2016) was selected as a proxy variable for economic policy uncertainty, and the GPR index constructed by Caldara and Iacoviello (2018) was selected as a proxy variable for geopolitical risk. Given the availability of representative indices of Asian stock markets and the index data, four representative indices of China, Japan, Korea and Singapore were selected as variables for this paper. The above data were monthly and normalized using Eviews. The EPR and GPR indices were obtained from the Economic Policy Uncertainty Index website, and the stock data were obtained from the Investing website.

2.2 Model Building

In this paper, we constructed the volatility spillover index based on the DY2012 method by first considering a weakly smooth VAR(k) with N variables:

$$x_t = \sum_{t=1}^{k} \phi_t x_{h-t} + \varepsilon_h \tag{1}$$

Where $\phi_t = (1, 2, 3 \cdots k)$ is a $N \times N$ parameter matrix, $\varepsilon \sim (0, \sum)$ is an independent disturbance term with the constant distribution. The moving average is denoted as $x_t = \sum_{t=0}^{\infty} A_t \varepsilon_{h-t}$, where the parameter matrix is A_0, a $N \times N$ unit matrix. In case that i is less than 0, $A_t = 0$; in case that i is greater than 0, A_t satisfies the recursion equation:

$$A_t = \phi_1 A_{t-1} + \phi_2 A_{t-2} + \cdots + \phi_k A_{t-k} \tag{2}$$

To prevent the results of variance decomposition from being affected by the ranking of variables, the KPSS method was used for prediction error variance decomposition, and the elements of the matrix were calculated by Eq. (3):

$$\theta_{ij}^{q}(B) = \frac{\delta_{ij}^{-1} \sum_{b=0}^{B-1} (e_k' A_b \sum e_j)^2}{\sum_{b=0}^{B-1} (e_k' A_b \sum A_b^i e_i)} \tag{3}$$

Where, $\theta_{ij}^{q}(B)$ is the element of the i-th row and j-th column of the solution matrix, and denotes the proportion of the total prediction variance of the i-th variable from the j-th variable. $\sum$ is the variance matrix of ε_h, δ_{ij} is the standard deviation of the error term of the jth equation, and the e_i is a column vector with element i being 1 and the remaining elements being 0. In $\sum_{j=1}^{N} \theta_{ij}^{q}(B) \neq 1$. θ_{ij}^{q} is normalized as:

$$\tilde{\theta}_{ij}^{q}(B) = \frac{\theta_{ij}^{q}(B)}{\sum_{j=1}^{N} \theta_{ij}^{q}(B)} \tag{4}$$

Then, it is concluded that: $\sum_{j=1}^{N} \tilde{\theta}_{ij}^{q}(B) = 1, \sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{q}(B) = N$. The specific spillover indices are constructed below:

2.2.1 Total Spillover Index

$$S^{q}(B) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^{q}(B)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{q}(B)} \times 100 = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^{q}(B)}{N} \times 100 \tag{5}$$

It measures the total spillover effect resulting from the interaction between N variables.

2.2.2 Directional Spillover Index

$$S_{\bullet \leftarrow i}^{B} = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^{q}(B)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^{q}(B)} \times 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^{q}(B)}{N} \times 100 \tag{6}$$

$$S_{i \leftarrow \bullet}^{B} = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^{q}(B)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{q}(B)} \times 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^{q}(B)}{N} \times 100 \tag{7}$$

$S_{\bullet \leftarrow i}^{B}$, $S_{i \leftarrow \bullet}^{B}$ distributions represent the total spillover of i to other variables and other variables to i, i.e., the To directional spillover index and the From directional spillover index.

3 Results and Discussion

3.1 Stationarity and Co-integration Test

First, the SSE Composite Index (SSEC) for the Chinese stock market, the Nikkei 225 (N225) for Japan, the Korea Composite Stock Price Index (KOSPI), and the DBS Group Holdings (DBSM) for Singapore, geopolitical risk (GPR) and economic policy uncertainty (EPU) data were standardized. Then, the ADF unit root test was used to test the stationarity of the six variables, and it was found that all the variables were stationary. Since SSEC, N225, KOSPI, DBSM, GPR, and EPU are integrated of the same order, Johansen's test can be used to determine the cointegration relationship among the variables. From the EViews output, at least four cointegration relationships were observed at the 5% significance level, which meant that there was a long-run equilibrium relationship among the six variables.

3.2 Static Spillover Index Analysis

The model was built based on the DY spillover index. Firstly, the VAR model of the above 6 series was built, and the optimal lag order was determined as order 1 using the AIC and SC criteria, and the forward prediction step was set as 10 and the rolling window length was 150 respectively in R language, and the spillover index analysis was performed based on this.

In Table 1, the spillover indices among SSEC, N225, DBSM, KOSPI, GPR, and EPU are presented. The non-diagonal values indicate that the variation of one variable is influenced by another variable, which is also called the spillover effect of another variable on that variable. It can be seen that the total spillover index was 31.18%, and that the directional spillover effect was also greater than zero, indicating that there was a spillover effect among the variables, and the interaction between the six variables could explain about 31% of the system variation. From the spillover effect of two variables, the spillover effects between DBSM and KOSPI and KOSPI and N225 were the most significant. The spillover effect of DBSM on KOSPI was 18.32%, the spillover effect of KOSPI on DBSM was 19.14%, while the spillover effect of KOSPI on N225 was 19.23%, and the spillover effect of N225 on KOSPI was 17.82%. It can be seen that the spillover effect values between two of these variables are similar but not exactly equal, which indicates that the spillover effect is bidirectional and asymmetric. The low spillover indices between any two of the other variables also indicates that there is a two-way spillover effect between them. From the values of net spillover index, the values of SSEC, GPR and EPU were negative, while the values of the remaining three variables N225, DBSM and KOSPI were positive, which indicated that SSEC, GPR and EPU were the receivers of risk spillover, while N225, DBSM and KOSPI were the transmitters of risk spillover.

3.3 Dynamic Spillover Index Analysis

The above spillover analysis was conducted on spillover indices among variables from a static perspective, but failed to reveal the dynamic effects among variables. In the following section, the dynamic spillover characteristics of SSEC, N225, DBSM, KOSPI, GPR, and EPU are analyzed using a rolling window to examine the volatility and risk spillover effect among the variables from the time dimension.

3.3.1 Total Spillover Index

Figure 1 shows the trend of the total spillover index for each variable during the sample period, which shows that the spillover index fluctuates from 30% to 38% among the variables. It indicated that there was a significant spillover effect among the variables, and that there were different responses to the spillover effect at different time points,

Table 1. Spillover Indices For SSEC, N225, DBSM, KOSPI, GPR, and EPU.

	SSEC	N225	DBSM	KOSPI	GPR	EPU	From
SSEC	–	7.24	7.80	9.92	0.18	0.77	25.91
N225	7.21	–	15.03	19.23	0.25	1.28	43.01
DBSM	6.06	17.84	–	19.14	3.10	0.13	46.28
KOSPI	7.07	17.82	18.32	–	3.75	0.30	47.26
GPR	0.21	1.75	5.40	3.89	–	1.72	12.97
EPU	2.79	4.01	0.67	3.05	1.10	–	11.63
To	23.34	48.66	47.22	55.24	8.39	4.21	187.05
NET	−2.57	5.65	0.95	7.97	−4.59	−7.42	31.18

Note: Data in the table are in %.

suggesting the time-varying characteristics of the spillover effect. The spillover index was low at about 31% between 2015 and 2016, and rose sharply in the second half of 2015. It was associated with the "stock market crash" in 2015, which intensified the external export of China's economic policy uncertainty, resulting in large fluctuations in the total spillover index. The total spillover index showed a slight decline from 2016 to 2017, and then stabilized until 2019, when it reached the highest peak in the sample period in 2020. In 2020, due to the COVID-19 epidemic outbreak, China's economic policy uncertainty towards other countries increased significantly, leading to a substantial increase in risk spillovers.

3.3.2 To Directional Spillover Index

From the trend of To directional spillover index of each variable in Fig. 2, we can conclude that the spillover indices of N225, DBSM and KOSPI on other variables fluctuated in roughly the same range from 45% to 60%. It can be seen that N225, DBSM and KOSPI had the most significant spillover effect on the other variables, with the effect on them reaching about 1/2. The second most influential variable was SSEC, with a fluctuation range of 22%–40% in To direction, followed by EPU and GPR, with fluctuation ranges of 5%–20% and 2%–12%, respectively, and their spillover effect on the other variables was smaller. The spillover effect of each variable increased significantly in both the stock market crash in 2015 and the COVID-19 epidemic in 2020, with KOSPI having the highest spillover effect of nearly 60% and GPR having the lowest spillover effect of about 5%. For the COVID-19 epidemic period alone, the spillover indices of KOSPI and DBSM were significantly higher than those of the other variables. It indicates that KOSPI had a significant impact on.

the remaining five variables for the stock market crash and the COVID-19 epidemic, while DBSM was only affected during the COVID-19 epidemic. In this regard, it can be seen that all Asian stock markets fluctuated to different degrees under the impact of the COVID-19 epidemic in 2020. Among the countries studied in this paper, Singapore

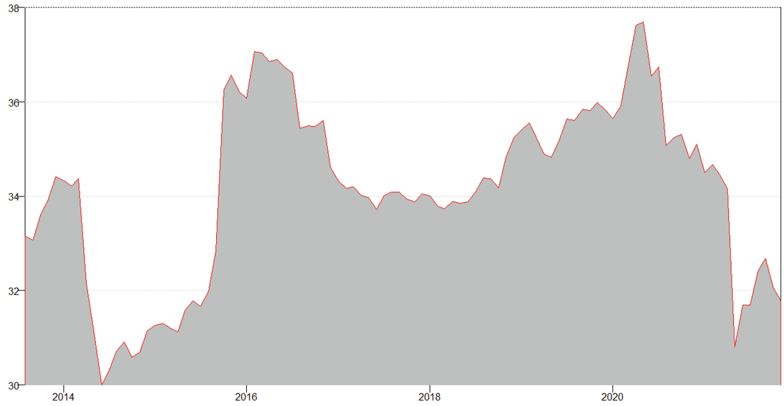

Fig. 1. Total spillover index between SSEC, N225, DBSM KOSPI, GPR, and EPU

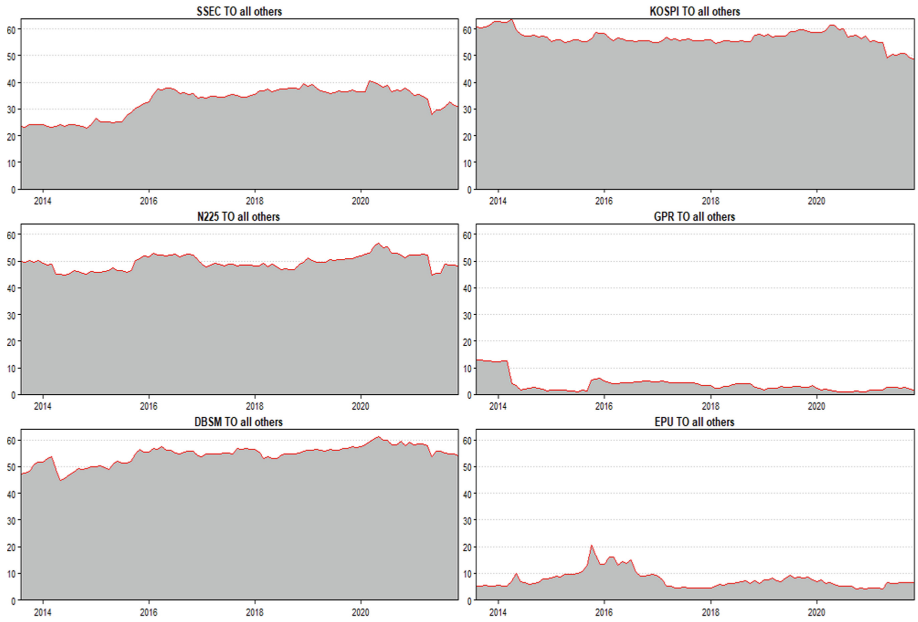

Fig. 2. To directional spillover indices among SSEC, N225, DBSM, KOSPI, GPR, and EPU.

and South Korea had the highest fluctuations, while Japan and China were the second most affected.

3.3.3 From Directional Spillover Index

As shown in Fig. 3, the trend of spillover indices in the From and To directions were similar, with N225, DBSM and KOSPI being the most affected by the spillover effect of other variables, with the effect range from 40% to 50%. However, unlike the above

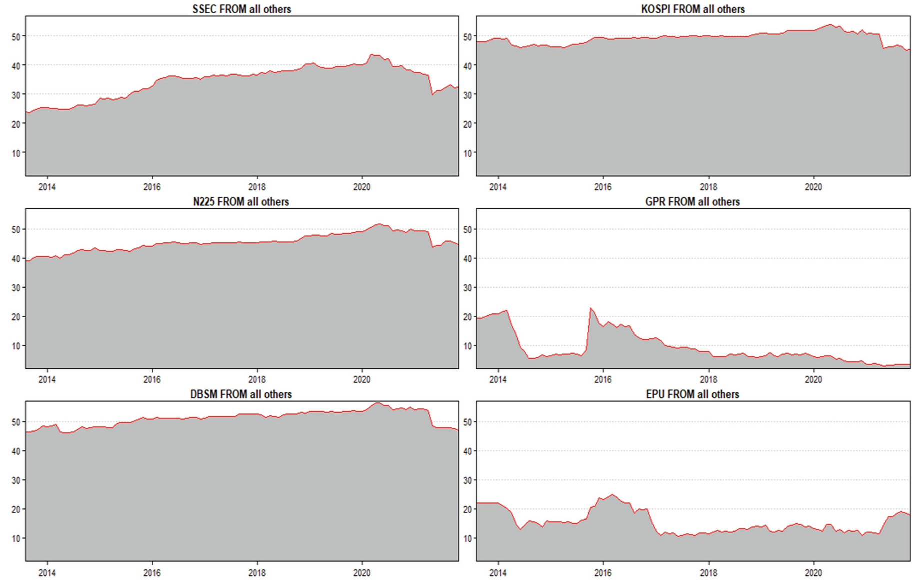

Fig. 3. From directional spillover indices among SSEC, N225, DBSM, KOSPI, GPR, and EPU.

case, the outbreak of the COVID-19 epidemic in 2020 made SSEC, N225, DBSM and KOSPI more susceptible to other variables than the stock market crash in 2015, and the DBSM was the most affected by the COVID-19 epidemic, with the effect value being the largest in the whole sample period. The spillover index of KOSPI during the COVID-19 epidemic was second only to that of DBSM. In 2021, there was a downward trend in all countries' stock markets. It also indicates that the outbreak of the COVID-19 epidemic would have an impact on the stock market of each country, but the magnitude of the impact would vary depending on the level of economic development, stock market vulnerability, and investor information. The most affected by the stock market crash in 2015 were GPR and EPU, as well as SSEC, with the spillover indices both starting to rise in the second half of 2015. GPR and EPU reached the maximum value of 22% and 25%, respectively, in the sample period at the time of the stock market crash. The SSEC, however, was less variable after the rise in 2015, until it reached a maximum of 43% in 2020.

Regarding the directional spillover indices, the spillover indices of N225, DBSM and KOSPI were large in the To and From directions, while the spillover indices of GPR and EPU were small and the spillover index of SSEC was moderate. Although the trends of the indices in the To and From directions were similar, there were significant differences in the values of the variations, which indicated that the spillover effect in the To and From directions was asymmetric.

3.4 Robustness Test

In order to investigate the robustness of the time-varying characteristics of the spillover effect, this paper modifies the length of the window period by making changes to the R language code and using rolling windows of length 120, 150, 200 and 220 for dynamic estimation, respectively.The obtained graphs have approximately the same trend, exhibiting peaks and troughs at the same time points, and the variation of the total spillover index does not change as the rolling window increases, which indicates that the above spillover effect study is robust.

4 Conclusions

4.1 Conclusions

This paper uses R language to calculate the DY spillover index and analyzes the spillover effects between the Shanghai Composite Index (SSEC), the Nikkei 225 Index (N225), the Korea Composite Index (KOSPI), and DBS Group Holdings (DBSM) in Singapore, geopolitical risk (GPR) and economic policy uncertainty (EPU) from both static and dynamic perspectives, respectively. Furthermore, we analyzed each variable and the spillover effects between them at the important time points of the stock market crash in 2015 and the COVID-19 epidemic in 2020. In the context of the COVID-19 epidemic, the following conclusions were drawn by combining the static spillover and dynamic spillover analyses:

First, from the results of the above R software calculations, these six variables selected in this paper include both risk receivers and risk transmitters. The net spillover indices of SSE Composite Index, geopolitical risk and economic policy uncertainty were all negative, suggesting that these three variables are the receivers of risk spillover; however, the net spillover indices of Nikkei 255, Korea Composite Index and DBSM were all positive, suggesting that they are the transmitters of risk spillover.

Second, from the static spillover indices, there was a relatively significant spillover effect between DBSM and KOSPI and between KOSPI and N225, and the spillover indices between any two variables indicated that the spillover effect between variables was asymmetric. From the dynamic spillover indices, the directional spillover indices of the variables had small peaks in 2015 and 2020, but the values were not equal, which indicated that the spillover effect of the variables was asymmetric.

Finally, the total spillover effect was greater than zero, indicating that about 1/3 of the system variation during the sample period could be explained by the interaction between the six variables. The spillover effect experienced a significant rise to the peak and frequent fluctuations during the stock market crash in 2015 and the COVID-19 epidemic in 2020, which indicates a significant increase in risk spillover at these two time points and a greater dampening effect on economic development.

4.2 Recommendations

Based on the analysis and conclusions of this paper, the following recommendations are given based on the current economic situation in China:

First of all, the risk of the epidemic should be prevented and policies should be formulated accordingly. After the outbreak of the COVID-19 epidemic, the Chinese stock market and the other stock markets in Asia suffered from significant risk spillover, causing stock market turbulence. In a volatile investment environment, investors are likely to suffer heavy losses, which will also affect investor confidence. In order to protect the stock market from continuous downturn, the government should formulate appropriate policies and set up an early warning procedure for the stock market to promote the smooth and orderly development of the stock market.

Second, regional cooperation should be strengthened to promote financial development. While further strengthening China's cooperation with Japan and Singapore in the Asia-Pacific region, the Chinese government should boost economic ties and financial cooperation with developed Western countries to facilitate the internationalization of China's stock market and the development of financial markets.

Finally, market vulnerability should be reduced to maintain the long-term stability of the stock market. In case of a large amount of short-term capital in the stock market, the stability of the stock market will be diminished. At this time, such short-term capital may also flow out with the change of unfavorable factors in the external market, which may lead to a drastic fall of the stock market or even a collapse. To prevent this situation, the government should encourage long-term stable capital to invest in the stock market to enhance the robustness of the stock market.

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