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Correlation Analysis of Stock Markets in the Belt and Road Regions

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Abstract

As a regional cooperation framework, the Belt and Road Initiative (BRI) aims to spur economic development by investing in infrastructure and improving connectivity between the countries in Asia, Europe, and Africa located along the Silk Road Economic Belt and the 21st Century Maritime Silk Road. Many studies have documented that BRI-related investment projects reduce trade costs, increase trade and investment flows, bring benefits to trading parties, and improve connectivity between countries along the Belt and Road.

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Financial integration is a critical aspect of intangible connectivity that is fundamental to and benefits from increased trade and investment flows between countries. This study examines the pairwise correlations between 39 stock markets in the Belt and Road regions from 2008 to 2018, focusing on the correlations between China and the other markets. We find that the correlation between two markets in the same region is greater than those in different regions. China has a higher correlation with markets in Southeast Asia and North and Central Asia than in other regions. The correlations fluctuate over time, but their relative rankings among market pairs remain stable. In the first half of 2015, there was an unusually low correlation between China and all other markets, most likely due to China's stock market bubble. Our systematic examination of stock market correlations in the Belt and Road regions sheds new light on the temporal and cross-sectional dynamics in these understudied financial markets. The findings suggest significant potential for financial integration in the Belt and Road regions.

Keywords

Belt and Road Initiative; emerging markets; frontier markets; Maritime Silk Road; Silk Road Economic Belt.

1. Introduction

During his visits to Central Asia and Southeast Asia in September and October of 2013, President Xi Jinping proposed the Belt and Road Initiative (BRI) as a new regional cooperation framework encompassing countries in Asia, Europe, and Africa. The initiative was formalized within China's 13th Five-Year Plan (2016–2020), and it has become one of the most widely debated aspects of China's evolving role in the global economy (EIU, 2016). With the approval of the State Council of China, the National Development and Reform Commission (NDRC), the Ministry of Foreign Affairs, and the Ministry of Commerce jointly issued an official document in March 2015, outlining the blueprint for the Silk Road Economic Belt and the 21st Century Maritime Silk Road (NDRC, 2015). The Belt connects China to the economies that are located along the ancient Silk Road across Asia and Europe. The Road links China's coastal cities to the economies of South East Asia, Africa, and Europe through maritime shipping routes. NDRC's, 2015, document elaborates on the BRI framework, which promotes connectivity and economic development in countries along the Belt and Road.

The BRI plays an important role in meeting the demand for infrastructure investments in the Belt and Road regions. An Asian Development Bank (ADB, 2017) study estimates that there is a need for physical infrastructure investment in Asia of approximately US$1.5 trillion annually for

the next 30 years. Since 2013, Chinese overseas direct investment (ODI) in BRI countries has increased significantly. According to several studies, Chinese ODI in BRI countries is affected by the host country's GDP, geographical distance, per capita income, and language networks (Shahriar *et al.*, 2019; Ma and Liu, 2020).

In addition to the effects on trade and investment flows, the BRI is likely to impact economic and social development in terms of national soft power, policy and regulatory enforcement, cultural exchanges, etc. Voon and Xu (2020), conducted the first empirical study of the BRI's impact on the national soft power and found that Chinese ODI in BRI countries along the land route significantly improved China's soft power.

The linkages between stock markets in the Belt and Road regions are an important aspect of financial integration. Understanding the spatial and temporal characteristics of the correlations between these stock markets is of great interest to both academic researchers and policymakers. As of March 2015, more than 60 countries were involved in the development of the Belt and Road projects. For 39 of these countries, we are able to identify the representative stock market indices from the Thomson Reuters Eikon system or the Bloomberg terminal. The MSCI Country Classification Standard classified two of them as developed markets, 16 as emerging markets, and 15 as frontier markets, with the remaining six as unclassified. Table 1 shows the names of these countries, their respective stock market indices, and the MSCI classification type.

Table 1. List of Countries and their Representative Stock Market Indices in the Belt and Road Regions.

Region	Country	MSCI[a]	Index Name
Southeast Asia	Indonesia	E	Jakarta SE Composite Index
	Malaysia	E	FTSE Bursa Malaysia KLCI Index
	Thailand	E	SET Index
	The Philippines	E	The Philippine Stock Exchange PSEi Index
	Singapore	D	FTSE Straits Times Index
	Vietnam	F	Vietnam Index
	Myanmar	U	Myanmar-Focused Asia Index
South Asia	India	E	NIFTY 500 Index
	Pakistan	F	KSE 100 Index
	Sri Lanka	F	CSE All Share Index
	Bangladesh	F	Dhaka Stock Exchange Board Index

Table 1. (*Continued*)

Region	Country	MSCI[a]	Index Name
North and Central Asia	South Korea	E	Korea SE Kospi Index
	Mongolia	U	Solactive Mongolia Performance Index
	Kazakhstan	F	KASE Index
West Asia	Turkey	E	BIST 100 Index
	Israel	D	Tel Aviv Main 125 Index
	Jordan	F	Amman Stock Exchange All Share Index
	Oman	F	Muscat SE General Index
	Lebanon	F	BLOM Bank Index
	Bahrain	F	Bahrain All Share Index
	Qatar	E	Qatar Exchange General Index
	UAE	E	Abu Dhabi Securities Exchange General Index
	Iraq	U	Iraq Stock Exchange Main 60 Index
	Kuwait	F	MSCI Kuwait Index
East Europe	Czech Republic	E	PX Prague SE Index
	Estonia	F	OMX Tallinn GI
	Hungary	E	Budapest SE Index
	Slovak Republic	U	SAX Index
	Bulgaria	F	Bulgarian Stock Exchange SOFIX Index
	Croatia	F	CROBEX Index
	Latvia	U	OMX Riga GI
	Lithuania	F	OMX Vilnius GI
	North Macedonia	U	Macedonian Stock Exchange 10 Index
	Poland	E	Warsaw SE WIG Poland Index
	Russia	E	MOEX Russia Index
	Bosnia	F	Sarajevo 10 Index
Africa	Egypt	E	EGX 30 Index
	South Africa	E	FTSE/JSE RAFT 40 Index

Notes: [a]MSCI market classification categories include the developed markets (D), the emerging markets (E), the frontier markets (F), and the unclassified (U).

Most prior studies that analyzed stock market correlations focused on developed markets, overlooking many frontier and unclassified markets in the Belt and Road regions. Although these studies have documented evidence on correlations for a subset of the stock markets along the Belt and Road, they lack knowledge about correlations concerning many of these markets. Our study aims to fill a knowledge gap by documenting the evidence on pairwise correlations between these markets, focusing on the correlations between China and the other markets.

The rest of this paper is structured as follows. The second section includes a synopsis of related studies. The third section discusses the data and research methodology. The fourth section presents the empirical results. The fifth section summarizes the findings and concludes the paper.

2. Literature Review

Many popular press and academic publications have examined the BRI from the perspectives of national development and international relations (Pettman, 2019; Pamungkas *et al.*, 2020; Wang, 2021). This study aims to investigate financial integration among countries in the Belt and Road regions; hence, we briefly review related BRI studies in the Economics and Management literature. The BRI provides significant opportunities for economic development in participating countries (Cheng, 2016). Infrastructure investment improves connectivity in these regions and increases bilateral trade and investment flows (Huang, 2016). According to a World Bank study published in 2018, implemented and planned BRI infrastructure projects would significantly reduce shipment times and trade costs (de Soyres *et al.*, 2019). The Belt and Road economies located along the economic corridors where projects are built would benefit the most, with shipment times and trade costs decreasing by up to 11.9% and 10.2%, respectively. Ramasamy and Yeung (2019) emphasized that developing better physical infrastructure and improving trade facilitation positively impact bilateral trade and that both approaches are mutually supportive — "One without the other will hamper trade flows." Baniya *et al.* (2020) also found that trade reforms, such as signing agreements beyond tariff reductions to lower border delays and have better market access, would increase trade flows. Meanwhile, Wang and Tian (2022) used an augmented gravity model to examine trade flows between China and its trading partners from 2012 to 2020, documenting evidence that the BRI has effectively strengthened China's global trade position and benefited both trading parties.

The BRI Vision document encourages countries to "work in concert and move toward the objectives of mutual benefit and common security", specifically "to improve the region's infrastructure, and put in place a secure and efficient network of land, sea, and air passages, lifting their connectivity to a higher level; further enhance trade and investment facilitation, establish a network of free trade areas that meet high standards, maintain closer economic ties, and deepen political trust; enhance cultural

exchanges; encourage different civilizations to learn from each other and flourish together; and promote mutual understanding, peace and friendship among people of all countries" (NDRC, 2015).

The BRI, as a grand public diplomacy architecture, has the potential to strengthen China's soft power. Soft power "rests on the ability to shape the preferences of others" and "fortifies the country's intangible assets such as an attractive personality, culture, political values and institutions, and policies that are being viewed as having moral qualities" (Nye Jr., 2005; Voon and Xu, 2020). Voon and Xu (2020), were the first to document empirical evidence on this critical issue. They used international survey data on soft power and Chinese ODI statistics from 2011 to 2016 to empirically test whether the BRI has raised China's soft power. Despite massive trade agreements and infrastructure investments in BRI countries since 2013, they found that the overall impact of Chinese ODI in BRI countries on China's soft power is not statistically significantly different from its impact in non-BRI countries. However, when the entire group of BRI countries are divided into BRI countries along the ancient Silk Road on land and those along the Maritime Silk Route, they found that Chinese ODI in the BRI countries along the land route significantly improved China's soft power. They attributed this finding to competitive political and economic factors that erode Chinese ODI's influence, predominantly in countries along the maritime route.

Most studies in the literature examining stock market correlations have focused on developed markets. Only a few studies have found evidence of correlations between stock markets along the Belt and Road, e.g., Palac-McMiken (1997) Flavin *et al.* (2002) Quinn and Voth (2008) Floros (2011) and Dajcman and Festic (2012). Palac-McMiken (1997), investigated market correlation in ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) between 1987 and 1995 based on the monthly market indices data. He found that, except for Indonesia, all markets were strongly correlated with Thailand, and Singapore was most closely correlated with Malaysia. Meanwhile, Flavin *et al.* (2002) studied the correlation between stock markets in 27 countries and found that both physical geography variables (e.g., distance and borders) and cultural geography variables (e.g., common language) influence the strength of market correlation between two countries. Quinn and Voth (2008) reviewed market correlation studies and concluded that global equity market movements

correlate. Floros (2011) recently investigated the correlation between the Egyptian and Israeli stock markets. Moreover, Dajcman and Festic (2012) and Trabelsi and Hmida (2018) analyzed the price co-movement of stock markets in several European countries. Chiang and Chen (2016) used daily trading stock indices from 1998 to 2015 to study correlations between China and international markets (Hong Kong, Taiwan, South Korea, Japan, the US, and Europe). They found that China has strong links with Hong Kong and other Asian markets, whereas its correlations with the US and European markets are less significant.

3. Data and Methodology

We identify the representative stock market index for 39 countries in the Belt and Road regions using data from the Thomson Reuters Eikon system or the Bloomberg terminal. They fall into six geographical regions: seven countries in Southeast Asia, four in South Asia, 10 in West Asia, three in North and Central Asia, 12 in East Europe, and two in Africa. We obtain the daily market index returns for South Africa and Kuwait from the Bloomberg terminal, and all other markets from the Thomson Reuters Eikon system. The returns cover the period from August 2007 to December 2018. The returns are all calculated in the local currency. Table 2 presents descriptive statistics for the daily returns on the 39 stock market indices.

Table 2. Descriptive Statistics of Each Index Return Series in 2008–2018.

	Descriptive Statistics						Autocorrelation		
	Mean	S.D.	Skewness	1st Q.	Median	3rd Q.	Lag 1	Lag 2	Lag 4
CSI 300	0.00%	1.74%	−0.34	−0.74%	0.04%	0.79%	0.027	−0.031	0.061
Indonesia	0.04%	1.31%	−0.46	−0.50%	0.10%	0.65%	0.111	0.003	−0.009
Malaysia	0.01%	0.71%	−1.05	−0.31%	0.02%	0.36%	0.140	0.030	−0.004
Thailand	0.03%	1.19%	−0.52	−0.49%	0.07%	0.61%	0.044	0.056	0.000
The Philippines	0.04%	1.22%	−0.69	−0.58%	0.07%	0.70%	0.110	−0.010	−0.017
Singapore	0.00%	1.09%	−0.02	−0.48%	0.01%	0.49%	0.026	0.008	0.026
Vietnam	0.01%	1.41%	−0.23	−0.70%	0.07%	0.76%	0.276	0.054	0.086
India	0.03%	1.34%	0.12	−0.58%	0.10%	0.65%	0.108	−0.015	0.014
Pakistan	0.05%	1.14%	−0.15	−0.47%	0.04%	0.60%	0.104	0.032	0.020
Sri Lanka	0.04%	0.88%	0.42	−0.33%	0.00%	0.36%	0.183	−0.014	0.050
Czech Republic	−0.01%	1.42%	−0.16	−0.60%	0.02%	0.61%	0.053	−0.056	0.024

Table 2. (*Continued*)

	Descriptive Statistics						Autocorrelation		
	Mean	S.D.	Skewness	1st Q.	Median	3rd Q.	Lag 1	Lag 2	Lag 4
Estonia	0.02%	1.08%	0.48	−0.38%	0.03%	0.42%	0.138	0.046	0.021
Hungary	0.03%	1.56%	0.16	−0.73%	0.04%	0.78%	0.053	−0.060	0.048
Slovak Republic	0.00%	1.19%	−0.72	−0.31%	0.00%	0.34%	−0.060	0.008	−0.017
Bulgaria	−0.03%	1.17%	−0.89	−0.47%	0.00%	0.44%	0.009	0.084	0.053
Croatia	−0.03%	1.16%	0.43	−0.40%	−0.01%	0.40%	0.044	−0.008	0.012
Latvia	0.03%	1.31%	0.78	−0.52%	0.02%	0.55%	0.002	0.102	−0.051
Lithuania	0.01%	1.05%	0.05	−0.30%	0.02%	0.35%	0.129	0.060	0.034
Bahrain	−0.02%	0.55%	−0.77	−0.27%	−0.02%	0.24%	0.143	0.061	0.012
Bangladesh	0.03%	0.81%	−0.03	−0.41%	0.02%	0.46%	0.129	0.035	0.084
Bosnia	−0.08%	1.13%	−9.94	−0.42%	−0.01%	0.32%	0.148	0.055	0.019
Egypt	0.02%	1.67%	−0.77	−0.77%	0.10%	0.92%	0.188	0.014	0.023
Iraq	0.51%	1.30%	6.63	−0.45%	−0.05%	0.30%	0.001	−0.002	0.004
Israel	0.01%	1.13%	−0.20	−0.47%	0.06%	0.56%	0.049	0.003	−0.007
Jordan	−0.02%	0.85%	−0.14	−0.33%	−0.02%	0.30%	−0.100	−0.014	−0.013
Kazakhstan	0.01%	1.79%	0.29	−0.68%	0.01%	0.73%	−0.247	0.053	0.027
Korea	0.01%	1.22%	−0.36	−0.49%	0.03%	0.60%	0.030	−0.033	−0.013
Kuwait	−0.02%	1.23%	−0.29	−0.55%	0.02%	0.56%	0.138	0.005	−0.006
Lebanon	0.02%	0.87%	−28.49	−0.16%	0.01%	0.20%	−0.040	0.021	0.002
Macedonia	−0.02%	1.12%	−0.42	−0.44%	−0.02%	0.39%	0.429	0.096	0.003
Mongolia	−0.08%	1.95%	1.05	−1.10%	−0.13%	0.89%	0.061	0.029	0.053
Myanmar	0.02%	0.93%	−0.06	−0.44%	0.03%	0.53%	0.059	0.027	−0.014
Oman	−0.02%	1.02%	−0.80	−0.31%	0.01%	0.32%	0.255	0.052	−0.043
Poland	0.01%	1.21%	−0.36	−0.57%	0.04%	0.62%	0.071	−0.029	0.006
Qatar	0.01%	1.34%	−0.26	−0.45%	0.04%	0.55%	0.078	−0.160	−0.030
Russia	0.03%	1.99%	0.79	−0.71%	0.01%	0.82%	0.058	−0.015	−0.023
South Africa	0.03%	1.25%	0.01	−0.62%	0.03%	0.72%	0.007	−0.050	−0.018
Turkey	0.04%	1.61%	−0.12	−0.79%	0.08%	0.93%	0.015	0.027	0.001
UAE	0.01%	1.08%	−0.15	−0.43%	0.03%	0.50%	0.204	−0.001	0.000

The CSI 300 Index is a capitalization-weighted index that represents the largest 300 firms listed in the Shanghai and Shenzhen Stock Exchanges in China. Figure 1 depicts the CSI 300 Index's cumulative daily returns from January 2008 to December 2018. A stock price bubble clearly developed in the first half of 2015 and burst in the middle of 2015.

Figure 2 plots the daily returns of the CSI 300 Index from January 2008 to December 2018. The time-series plot shows time-varying volatility and a

Figure 1. Cumulative Daily Returns of the CSI 300 Index, 2008–2018.

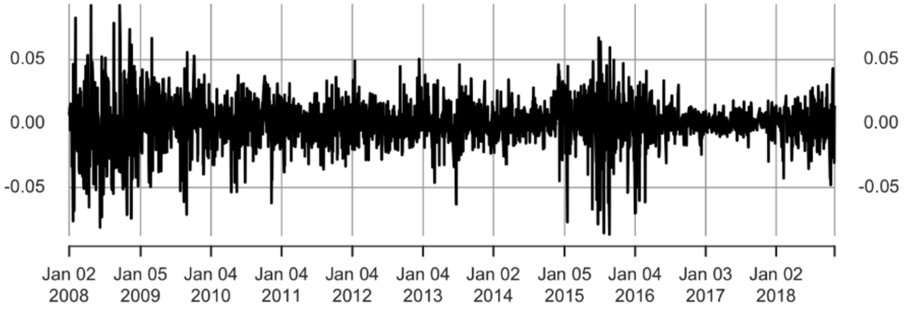

Figure 2. Daily Returns of the CSI 300 Index, 2008–2018.

distinct volatility clustering phenomenon, indicating that large changes in stock returns tend to occur after large changes, and small changes are frequently followed by small changes in stock returns (Mandelbrot, 1963). This phenomenon can be seen in our sample's time-series plot of all stock market index return series. Hence, we must develop statistical models that capture these features in stock market index returns so that our estimation of cross-market correlation is not biased by non-constant conditional variance in stock returns.

We consider the autoregressive moving-average (ARMA) models for the mean equation of index returns. The ARMA(p, q) model combines AR and MA parts and can be represented by Equation (1), where p and q refer to the orders of autoregressive terms and moving-average terms, respectively,

$$X_t = c + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \sum_{i=1}^{p} \varphi_i X_{t-i}. \quad (1)$$

We test the ARMA(1,1) and AR(1) models to fit the daily index return series and find little evidence supporting an average moving effect. As a result, we use the AR(1) model for all the stock market indices in our analysis.

However, the ARMA models are incapable of producing time-varying conditional volatility. Engle (1982) introduced the autoregressive conditional heteroskedasticity (ARCH) model to study the change in conditional variance over time, in which the variance at time t is a function of the squared residual errors in previous periods. Because the ARCH model specifies conditional variance as a linear function of past squared errors, it can generate the volatility clustering phenomenon in daily index returns. Bollerslev (1986) improved the ARCH model by including past conditional variance, yielding the generalized autoregressive conditional heteroskedasticity (GARCH) model in Equation (3),

$$\epsilon_t = \sigma_t e_t, \tag{2}$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2. \tag{3}$$

We apply the AR(1)–GARCH(1,1) model for all of the daily index return series in our analysis. We use the residuals to estimate the correlation coefficient between any two markets in our sample. To investigate the dynamics in cross-market correlation over time, we follow a rolling window approach to estimate the correlation coefficients daily. More specifically, for any pair of two markets on a given day, we estimate the correlation coefficient of the two markets using the residuals from the AR(1)–GARCH(1,1) model that fits to each market index in the last 100 days. Note that our study includes 38×39 pairs of markets. We obtain a time series of daily estimates of the correlation coefficient for each pair from 2008 to 2018.

4. Results and Discussion

4.1. *Correlations between markets within and across regions*

This subsection explores the spatial and temporal characteristics of the correlations between stock markets in the Belt and Road regions. First, we examine the overall picture of market correlations within and across geographical regions. We calculate the time-series mean of the daily correlation

Table 3. Average Correlations for Two Markets Within and Between Regions.

	Southeast Asia	South Asia	North and Central Asia	West Asia	East Europe	Africa
Southeast Asia	0.319					
South Asia	0.127	0.056				
North and Central Asia	0.264	0.102	0.217			
West Asia	0.107	0.065	0.084	0.079		
East Europe	0.160	0.082	0.153	0.078	0.148	
Africa	0.222	0.115	0.204	0.129	0.184	0.170

coefficients to estimate the correlation coefficient of any pair of two markets. We then calculate the average of the time-series means across all pairs with two markets in the same or two different regions. Consider Southeast Asia as an example. The seven countries in this region form 42 pairs, resulting in 42 correlation coefficients. We use the rolling window approach for each pair to obtain the daily correlation coefficients in 2008–2018 and calculate the time-series mean of these daily correlation coefficients. Table 3 reports the average of the correlations between any two markets, whether they are in the same or different regions. For example, Southeast Asia is in the first row and first column; thus, the number 0.319 at the intersection of the first row and the first column represents the average of the cross-market correlations of the 42 pairs of Southeast Asian markets. Similarly, because South Asia is in the second row and contains four countries, the number 0.127 at the intersection of the second row and the first column represents the average of the cross-market correlations of the 28 ($= 4 \times 7$) pairs with one market in South Asia and the other in Southeast Asia.

In general, Southeast Asian countries have a higher correlation with other countries both within and across the region. The correlations between Southeast Asian countries have a mean of 0.319, the highest one among the six regions. Meanwhile, between Southeast Asian and North and Central Asian countries, the average cross-region correlation is 0.264, and the average cross-region correlation between Southeast Asian and East European countries is 0.160. Some countries with very high correlations are Korea and Malaysia (0.457), Singapore and India (0.473), Singapore and Korea (0.548), Turkey and Poland (0.451), Israel and Czech Republic (0.480), Israel and Macedonia (0.469), and Poland and South Africa (0.467).

We also find that, regardless of geographical proximity or economic development, some countries have very low correlation with all other markets. For example, Lebanon's correlation coefficients with the other 38 countries are almost all negative, with the average correlation coefficient being −0.033. Slovak Republic, Bosnia, Sri Lanka, Bangladesh, Jordan, Iraq, and Bahrain also correlate poorly with the other markets. The average correlation coefficient of Slovak Republic is only 0.016, whereas the average correlation coefficient of Bosnia and Bangladesh is around 0.023.

Next, we report our observations about the cross-market correlation of countries in each region without tabulating the results. First, among the seven Southeast Asian countries, Singapore, Myanmar, Thailand, and Malaysia have a relatively higher correlation (around 0.4) with other Southeast Asian countries. Myanmar has an extremely high correlation with Thailand, with a mean of 0.725, indicating a strong correlation that could be attributed to frequent border trading with Thailand. Furthermore, the correlation coefficient between Myanmar and Singapore is 0.549, which is quite significant. Indonesia and the Philippines have a moderate correlation with the remaining countries, with a correlation coefficient of around 0.3. Conversely, Vietnam has a much lower correlation with all other countries, including its neighbor Thailand, with an average correlation coefficient of only 0.125. Overall, Southeast Asian countries have a relatively high correlation with their regional peers.

Second, the four South Asian countries have very weak correlations; the only correlation coefficient that exceeds 0.1 is between India and Pakistan, and the other correlation coefficients range from −0.004 to 0.073. Given that all of the correlation coefficients are close to zero, it is safe to conclude that, despite their geographical proximity, these four countries' stock markets are nearly uncorrelated.

Third, we classify Korea, Mongolia, and Kazakhstan in North and Central Asia. These three countries have correlation coefficients of 0.167, 0.206, and 0.278, respectively, which are all in the middle of the observed cross-market correlation coefficients. Although they are not geographically neighboring countries, their stock markets are correlated to certain extent.

Fourth, the correlations between West Asian countries vary substantially. The correlation coefficients are 0.39 between Turkey and Israel and 0.36 between Qatar and UAE. Kuwait also has a relatively high correlation coefficient of about 0.19 with Qatar and UAE. However, although the

majority of the other correlation coefficients range between 0.05 and 0.15, the correlation between Iraq and Lebanon with other countries is extremely low, if not negative. Lebanon has a negative correlation coefficient with most West Asian countries, e.g., −0.149 with Turkey and −0.125 with Israel.

Fifth, most of the correlation coefficients among the 12 East European countries range between 0.1 and 0.27. For example, the correlation coefficient is 0.27 between Croatia and Czech Republic, is 0.195 between Latvia and Estonia, and is 0.129 between Hungary and Bulgaria. Meanwhile, the average correlation coefficient across all the pairs of East European countries is 0.148. Poland and Czech Republic have the highest correlation coefficient of 0.547, whereas a few countries have high correlation with others, such as Czech Republic and Hungary (0.496), Czech Republic and Russia (0.469), Hungary and Poland (0.533), Hungary and Russia (0.417), and Poland and Russia (0.512). Meanwhile, Slovak Republic has an extremely weak correlation with all other countries, with an average correlation of only 0.009. In particular, the correlation between Czech Republic and Slovak Republic is only −0.00045, even though they are next to each other geographically.

Lastly, Egypt and South Africa, the only two countries in Africa, have a correlation coefficient of 0.170 on average.

4.2. *Correlations between China and other markets*

The previous subsection focused on the average cross-market correlation between markets in the Belt and Road regions, excluding China, from 2008 to 2018. In the preceding discussion, the temporal fluctuation in cross-market correlation is ignored. In this subsection, we examine the correlation between China and the other markets, paying special attention to how it changes over time. The rolling window method is used to generate a time series of daily estimates of the correlation coefficient between China and each of the other 38 markets. Table 4 shows the descriptive statistics for each market's daily correlation estimates.

Among the Southeast Asian countries, Vietnam has the lowest mean correlation coefficient of 0.109, whereas Singapore has the highest mean of 0.322. The medians are nearly identical to the means. The standard deviations are comparable across all countries. Singapore, Indonesia, Malaysia, Thailand, and the Philippines have negative skewness, whereas Vietnam and Myanmar have positive skewness.

Table 4. Descriptive Statistics of the Correlation Between China and Other Markets.

	Mean	S.D.	Skewness	1st Q.	Median	3rd Q.
Southeast Asia						
Indonesia	0.244	0.170	−0.125	0.136	0.239	0.362
Malaysia	0.236	0.149	−0.112	0.133	0.239	0.341
Thailand	0.232	0.143	−0.252	0.134	0.232	0.352
The Philippines	0.184	0.165	−0.154	0.066	0.182	0.313
Singapore	0.322	0.171	−0.761	0.220	0.342	0.454
Vietnam	0.109	0.142	0.403	0.006	0.103	0.197
Myanmar	0.223	0.151	0.115	0.117	0.196	0.337
South Asia						
India	0.246	0.124	−0.138	0.145	0.254	0.342
Pakistan	0.069	0.146	0.219	−0.029	0.060	0.161
Sri Lanka	0.039	0.137	0.195	−0.054	0.029	0.125
Bangladesh	−0.011	0.162	−0.349	−0.090	−0.013	0.076
North and Central Asia						
Korea	0.333	0.151	−0.611	0.223	0.354	0.449
Mongolia	0.290	0.156	−0.157	0.172	0.288	0.428
Kazakhstan	0.182	0.138	−0.366	0.084	0.193	0.283
West Asia						
Turkey	0.102	0.140	0.084	0.010	0.091	0.202
Israel	0.142	0.139	0.089	0.046	0.140	0.232
Jordan	0.051	0.134	0.048	−0.056	0.047	0.155
Oman	0.095	0.162	0.108	−0.021	0.092	0.207
Lebanon	−0.086	0.151	0.138	−0.193	−0.087	0.015
Kuwait	0.040	0.150	0.344	−0.064	0.029	0.140
Iraq	0.033	0.140	−0.021	−0.039	0.042	0.120
Bahrain	0.019	0.148	−0.349	−0.070	0.036	0.125
Qatar	0.157	0.161	−0.051	0.038	0.169	0.276
UAE	0.129	0.150	0.590	0.026	0.112	0.214
East Europe						
Czech Republic	0.183	0.119	0.313	0.105	0.177	0.248
Estonia	0.148	0.150	−0.078	0.044	0.146	0.260
Hungary	0.142	0.130	0.293	0.051	0.131	0.227
Slovak Republic	0.024	0.141	−0.334	−0.051	0.029	0.119
Bulgaria	0.109	0.133	−0.445	0.033	0.113	0.204
Croatia	0.140	0.148	0.222	0.022	0.134	0.244
Latvia	0.071	0.132	0.214	−0.024	0.074	0.160
Lithuania	0.128	0.157	0.063	0.012	0.111	0.255
Poland	0.194	0.133	−0.201	0.099	0.190	0.301
Macedonia	0.072	0.141	0.168	−0.036	0.075	0.171

Table 4. (*Continued*)

	Mean	S.D.	Skewness	1st Q.	Median	3rd Q.
Russia	0.189	0.134	−0.169	0.087	0.195	0.299
Bosnia	0.016	0.121	0.245	−0.067	0.012	0.087
Africa						
Egypt	0.086	0.164	−0.129	−0.024	0.079	0.211
South Africa	0.233	0.130	−0.316	0.147	0.244	0.326

Among the South Asian countries, India shows a high correlation coefficient with China, whereas Pakistan and Sri Lanka have a low correlation. The mean correlation coefficient for India is 0.246, whereas for Pakistan and Sri Lanka, its values are 0.069 and 0.039, respectively. Bangladesh demonstrates a negative correlation, with a mean correlation coefficient of 0.011.

Korea has the highest correlation coefficient of the three North and Central Asian countries, with a mean correlation coefficient of 0.333. Meanwhile, Mongolia has a mean correlation coefficient of 0.29 due to its proximity to China. Kazakhstan has a relatively weaker correlation with China than the other two countries, with a mean correlation coefficient of 0.182.

Most West Asian countries have weak correlation with China in 2008–2018. Qatar has the highest mean correlation coefficient of 0.157, whereas Bahrain has the lowest mean of −0.019. In terms of African countries, Egypt has a very low correlation with China, with a mean of 0.086, whereas South Africa has a relatively higher correlation, with a mean of 0.223, which is higher than all East European markets but lower than many Asian countries.

All East European countries have relatively weak correlation with China; none of their mean correlation coefficients exceed 0.2. Among these countries, Slovak Republic and Bosnia have extremely weak correlations with mean values of only 0.024 and 0.016, respectively, whereas Poland, Russia, and Czech Republic have relatively strong correlations with the mean values of around 0.19. For most countries, the median is close to the mean.

To better understand the cross-sectional and temporal variations in the correlation between China and the other markets, we construct heat maps

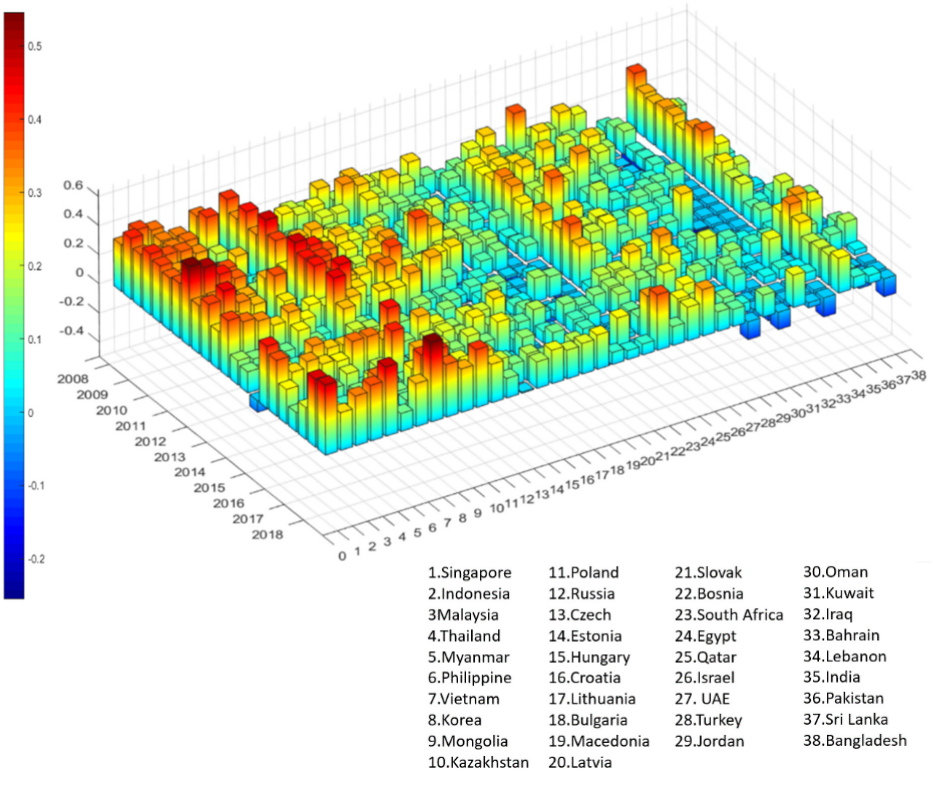

Figure 3. (Color online) The 3D Heat Map of the Correlation Between China and the Other Markets (Top View).

of the cross-market correlation in color using the time series of daily estimates of the correlation coefficients. Figure 3 depicts a three-dimensional (3D) colored heat map. There are 38 countries and 22 half-year windows in 2008–2018. Hence, the 3D heat map in Figure 3 has 38 columns representing countries and 22 rows for each country. Each column's height is equal to the average of the daily estimates of the correlation coefficient between China and one market over a half-year period. The correlation coefficient on average can be either positive or negative. The columns for positive correlation appear on the upper side of the heat map, whereas negative correlation columns appear on the opposite side. The columns in Figure 3 are colored according to the color scale on the side of the heat map. As the correlation coefficient changes from negative to positive, the color changes from dark blue to dark red. Figure 4 depicts the heat map's bottom view to better understand the distribution of negative correlation coefficients.

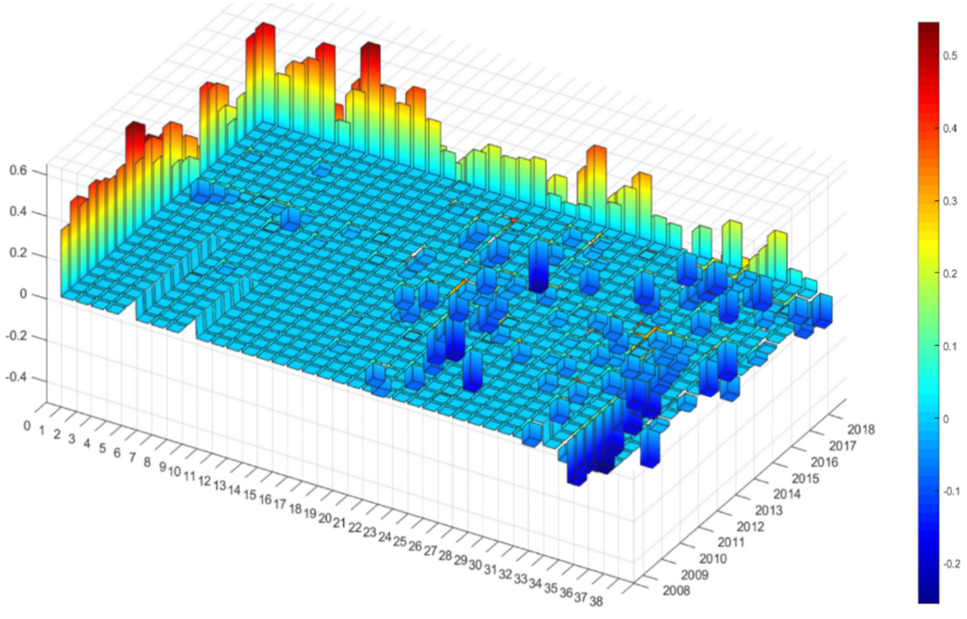

Figure 4. (Color online) The 3D Heat Map of the Correlation Between China and the Other Markets (Bottom View).

Figures 3 and 4 show that all markets in Southeast Asia and North and Central Asia have a high correlation with China from 2008 to 2018. Except for India and South Africa, most markets in West Asia, South Asia, Africa, and East Europe have a low correlation with China. Meanwhile, Lebanon has a negative correlation for most of the time. Slovak Republic has a negative correlation with China in 2011–2013, but it has a positive correlation in recent years. Interestingly, Singapore, Indonesia, and Malaysia have a negative correlation in the first half of 2015, despite having a very high correlation in the rest of the year.

The 3D heat map columns may obscure some patterns; thus, we create two two-dimensional (2D) heat maps in Figure 5 that reflect the top view of the heat map in Figure 3 and the bottom view of the heat map in Figure 4. Figure 5 shows that the correlation between China and all other markets is unusually low in the first half of 2015, even for countries like Singapore, Korea, and Mongolia, which have highly positive correlation with China in other periods. This is unlikely due to any bilateral change between China and any country. One possible explanation is the bubble in China's stock market in 2015, as shown in Figure 1, in which China's stock market index increased dramatically in the first half of 2015 before collapsing in the middle of 2015.

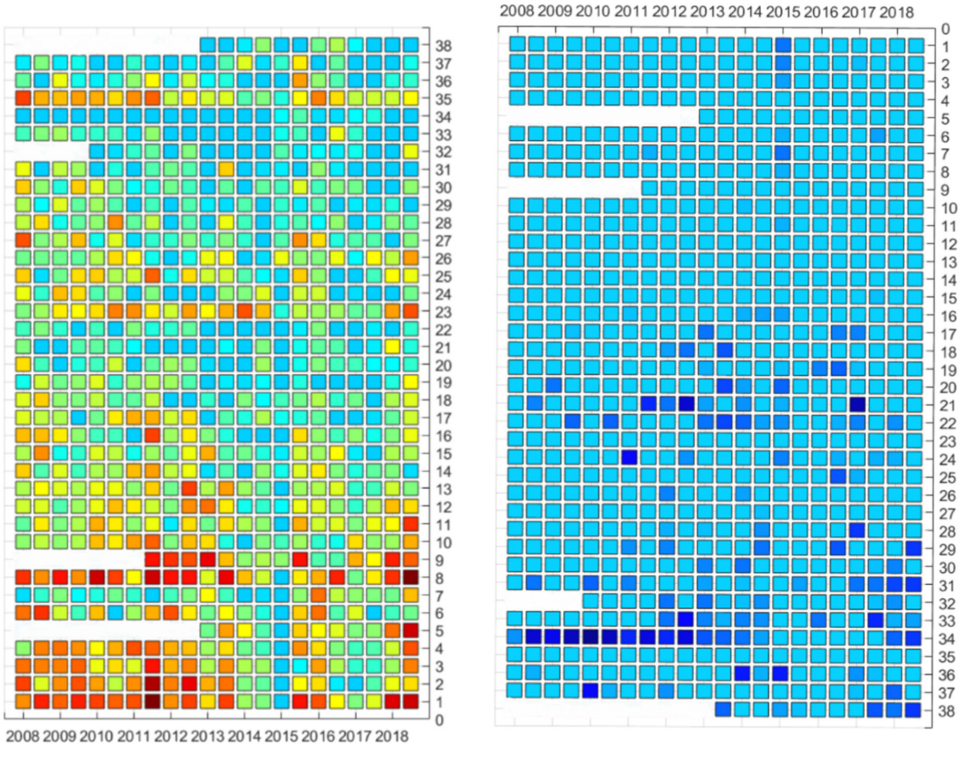

Figure 5. (Color online) The 2D Heat Maps of the Correlation Between China and the Other Markets.

5. Conclusion

This paper examines the correlations among 39 stock markets in the Belt and Road regions from 2008 to 2018, emphasizing the correlation between China and the other markets. We obtain daily returns on the representative market indices and estimate the cross-market correlation coefficients after removing the serial correlation in each market's daily return series.

This study has several interesting findings. First, among all the markets under study, Southeast Asian markets have the strongest correlation with China on average, whereas some markets in East Europe and South Asia have the weakest. China has a higher correlation with markets in Southeast Asia and North and Central Asia than in other regions. Second, markets within the same geographical region tend to be more correlated than markets outside the region. However, there are notable exceptions. For example, Southeast Asian markets have a high correlation with markets both within and outside the region, whereas South Asia and West Asia

have a low correlation with their neighboring markets. Third, although cross-market correlations fluctuate over time, their relative ranking across market pairs remains consistent. In the first half of 2015, there was an unusually low correlation between China and all other markets, most likely due to China's stock market bubble.

These findings raise questions that merit further investigation. For example, why do the Southeast Asian markets highly correlate with Chinese markets? Although neighboring countries tend to have a high correlation, why do some non-neighboring markets, such as Singapore, Qatar, and China, also have high correlation? Meanwhile, why do neighboring South Asian countries have such a low correlation with one another? Some ad-hoc answers to these questions can be provided; e.g., Pamungkas *et al.* (2020) argued that Southeast Asian countries have close geographical and cultural ties with China due to their location along the Maritime Silk Road. A thorough investigation of the economic, financial, geographical, cultural, and historical factors that may influence the correlation between these markets would necessitate a systematic approach.

Overall, our results suggest that the Belt and Road regions have significant potential for financial integration. We call for more research to understand the critical factors influencing the level of cross-market correlation in these regions and to determine the extent to which the BRI connectivity projects promote financial integration within and beyond these regions.

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