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A Catering Perspective of the Banking Sector Markets: Evidence from a Cross-Country Analysis

Maryam Nafisi-Moghadam[*], Azza Béjaoui[**], Ahmed Jeribi[***], Imran Yousaf[§]

Abstract: In this paper, we attempt to analyze and better apprehend the nature, structure and dynamics of connections between bank stock indices of different countries in G7 and BRIC regions during the outbreak of tremendous events. For this end, we apply the bi- and multi-variate wavelet method on banking sector indices during the period 1/1/2016 to 4/28/2023. The empirical findings show that the banking sector indices' comovement between the US and other markets tends to change in both short- and long-term and depend on region/country. Such connections are highly affected by the outbreak of tremendous events (crisis/pandemic). In particular, the impact of the SVB collapse on such connections seems to be dissimilar among countries and regions. The findings could have insightful information for investors and portfolio managers and call for stronger emphasis on the suitable banking regulatory environment.

Keywords: comovement; multivariate wavelet analysis; the SVB collapse.

JEL classification: G15; G20.

[*] University of Tabriz, Iran; e-mail: *nafisi1988@gmail.com*.
[**] Higher School of Commerce of Tunis, University of Manouba; QuanLab, Tunisia; e-mail: *bjaouiazza2@yahoo.fr* (corresponding author).
[***] Faculty of Economics and Management of Mahdia, Tunisia; e-mail: *ahmedjeribi07@yahoo.fr*.
[§] College of Business Administration, Prince Sultan University, Saudi Arabia; e-mail: *imranyousaf.fin@gmail.com*.

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1. INTRODUCTION

Overall, the banking industry is a substantial part of the economy around the world (Pandey *et al.*, 2023). It is characterized by specific features in comparison to other economy's sectors (Baumöhl *et al.*, 2022) as banks successfully perform important functions to better foster the economy's performance (Allen, 1990). Notwithstanding its far-reaching importance, the banking sector still remains fragile. That is why any bank bankruptcy could have tremendous and adverse effects (Cowan *et al.*, 2022) on other financial institutions in the sector through interbank connections from different perspectives (e.g. counterparty linkages related to liability/asset liability positions). Even if such connections are important for the stability of the financial system, they intensify the systemic risk during turbulent times. Not only that, but it can also imply risk contagion from such sector to other financial markets and even the real economy. Many events including the global financial crisis, the European sovereign debt crisis and the Covid-19 pandemic have increasingly shaken the national and international financial markets (Foglia *et al.*, 2022) and adversely impacted investor confidence. In this regard, the failure of Silicon Valley Bank (SVB) which is the 16th greatest bank in the United States led to the financial losses ($billions) in deposits and investments and arose against the backdrop of a changing tech industry during the health crisis (Yadav *et al.*, 2023). According to Vo and Le (2023), greater debt investments, small equity investment and a strongly concentrated depositor base. The collapse of the Silicon Valley Bank and then two other US banks (Signature Bank and Silvergate) implied a strong reaction among financial stress indicators given that depositors and investors were worried about downturn which may transform into global financial crisis (Dosumu *et al.*, 2023).

From an academic standpoint, many researchers have started to examine the effect on the SVB fall on the banking system and financial markets. For instance, Dosumu *et al.* (2023) investigate how social media increases bank runs using the recent bank turmoil in the United States. They display that social media offer a conduit through which an immediate adverse and substantial effect of the bank crisis transmits among global investor sentiments and market outcomes. They also show a substantial (resp. insignificant) spillover effect of the turmoil on G7 and European (resp. Asian and African) economies. Pandey *et al.* (2023) analyze the effects of Silicon Valley Bank failure on global stock markets. The magnitude of such effect is well-documented in developed markets. They also report that such collapse seems to be dissimilar among all countries. Yousaf and Akhtaruzzaman *et al.* (2023) study the effect of the SVB collapse on US market sectors based on event study approach. They report significant and negative abnormal returns on the event date only for the real estate, materials and financial sectors. They also display that the financial sector records the most important effect. Yadav *et al.* (2023) explore the influence of SVB failure on the top nine global equity indices. They report that the steep sell-off of equities can be attributed to the bank run on March 10, 2023. They afterwards indicate the substantial effect of SVB fall on the global equity markets with contagion effects of such crisis.

On the other hand, and leafing through literature on financial contagion and cross-border linkages, it is worth noting to mention that bank collapses could substantially and negatively influence national and international stock markets (Bellia *et al.*, 2022). It could be well-documented for community/small banks (e.g., Toussaint-Comeau *et al.*, 2020) and amid economic stressful times. Some studies report that factors (e.g. the kind of bank asset holding) impact the effect of bank bankruptcy on financial markets (Caiazzo and Zazzaro, 2023)

whereas other ones (e.g. interbank loans, liquidity and market factors) could contribute to the degree of systemic risk (e.g., Brunnermeier *et al.*, 2020; Meuleman and Vander Vennet, 2020). Strikingly, the interconnection among markets has been investigated using various approaches and techniques. As a matter of fact, many researchers have interestingly tried to apprehend a great degree of dependence and contagion across bank sectors within and among countries and regions during crisis periods (e.g., Black *et al.*, 2016; Toussaint-Comeau *et al.*, 2020; Zedda and Cannas, 2020).

Based on this crux, the purpose of this study is to analyze the structure and dynamics of connections between bank stock indices of different countries in G7 and BRIC regions during the outbreak of tremendous events such as the Covid-19 pandemic and the SVB collapse. Herein, it seems to be relevant to analyze the context of BRIC and highly industrialized (G7) countries given that BRIC countries are emerging economies along with opportunities for growth and investment (Sawal and Anjum, 2023) and not much is known about how connections between bank stock indices of different countries in G7 and BRICS regions. The regulators of BRIC countries have implemented more liberal financial policies with the aim of deleting regulatory obstacles to competition which produces efficiency gains, restricts bank fragility and fosters financial stability (IBRD, 2020). On the other hand, the regulatory practices (e.g. the banks operating systems) in G7 countries seem to be the benchmark for the other economies to follow (Chortareas *et al.*, 2012). Oredegbe (2022) analyzes the banking industry stability in G7 and BRICS during the period 2005-2014 and displays that stability level in a previous period influences stability during the subsequent period. They show that competition enhances stability. Economic growth improved stability in BRICS. Interestingly enough, the advent of unexpected and adverse events such as the Covid-19 pandemic and the SVB collapse have revived the debate on the interaction of banking sector, financial stability, and financial markets. By doing so, we try not only to offer insights into the time-varying magnitude of potential contagion impacts of tremendous events (e.g. a bank fall) on financial markets but also the dynamic connectedness among financial institutions. Together, it can help different stakeholders to establish an insightful picture of contagion dynamics within national/international financial system. From a methodological standpoint, we use the wavelet approaches which allow us to better apprehend the lag-lead relationship, phase difference and correlation framework in the frequency-time domain. Indeed, such methods are considered as frequency-time domain approaches based on frequency-time decomposition. They distinguish from other methods such as (A)DCC models by offering more interesting information based on time and frequency domains (Rua and Nunes, 2009). Therefore, they offer some insights into investor behavior and investment horizons. In particular, the wavelet methods help to analyze the comovements among indicators through time and frequencies (high, medium and low).

This study contributes to literature in different ways. First, we investigate the potential connections among banking sector stocks for different regions (developed and emerging countries). As a matter of fact, delving into the available literature on the cross-country analysis of international banking sectors seems to be narrow; nevertheless, some studies have endeavored to investigate return transmission and volatility spillover effects in international sector stocks. Second, we analyze the nature and dynamics of banking sectors' comovements during a crisis/pandemic. Despite other previous studies which particularly analyze the impact of specific adverse event (e.g. the Covid-19 pandemic), we try to the behavior of comovements with the outbreak of different events. This allows us to foster insights into the connectedness of banking sectors in different regions and enhance financial regulations.

Third, this study can provide insightful information to understand the resilience/fragility of banking systems to the intensity of unprecedented events. Finally, the research lacks studies explicitly investigating bank failures' effect on cross-border linkages. That is why this paper contributes to the literature by providing fresh evidence of the dynamics and magnitude of the effect of the SVB bank run on the connectedness between banking sectors in different regions.

Overall, foreshadowing the main empirical findings, one might document that exploring the time-varying frequency-time connectedness of US bank stocks and bank stocks in different regions in multi(bi)-variate structure show insightful empirical results. First, the linkages between assets seem to vary both long- and short-run. Some cross-correlations tend to be higher due to the advent of SVB fiasco and Ukraine-Russia war. So, the nature of negative events affects significantly the asymmetric dynamics of comovements through assets.

The structure of this paper is as follows. A set of studies exploring the effect of adverse events on the banking sector stocks' comovements is reported in Section 2. Section 3 clearly presents the methodology. Data description and descriptive statics are reported in Section 4. The estimation results and interpretations are presented in Section 5. Finally, Section 6 concludes and discusses.

2. LITERATURE REVIEW

Many researchers have interestingly investigated the connectedness among banking sectors in different regions, particularly with the outbreak of tremendous events such as the Covid-19 pandemic and the SVB failure. As a matter of fact, Rua and Nunes (2009) use the wavelet analysis to clearly depict how international stock returns relate in the frequency and time domains. Tiwari *et al.* (2016) tend to evaluate the level of contagion, comovements and rolling correlation among the PIIGS and those of Germany and the UK by using the wavelet method. They show that, in the short-term, the correlation level is stronger during financial distress episodes. However, in the long-term, the comovements exist for different time horizons. Albulescu *et al.* (2017) analyze the contagion and comovement among six international stock index futures markets by using a frequency-time method. The empirical results show that comovements among the international markets manifest in the long term. However, the contagion phenomenon linked to the very short-term horizon exists in the case of the European markets due to their level of integration. Jokipii and Lucey (2007) profess that the comovements between the Eastern and Central European banking sectors are greatly attributed to the contagion effect. Bouvatier and Delatte (2015) display the international banking integration outside the Euro zone has increasingly reinforced after the financial crisis. Mensah and Premaratne (2018a) study how the banking systems in different countries can commove with each other. They report that the banking sector returns connections changes during bull and bear markets. They also indicate that average dependence achieve moderate levels, even if dependence among the banking sectors of the developed Asian markets are quite greater than the emerging ones. Mensah and Premaratne (2018b) investigate the degree of integration for ASEAN and global markets during the period 2000-2012. They find high correlation between markets over time.

Arreola Hernandez *et al.* (2020) show that the most substantial emerging market spillover receivers and transmitters appear to be banks from Brazil. They also indicate that comovements between developing market banks seems to be more significant than the American institutions. Hanif *et al.* (2021) investigate the effects of Covid-19 pandemic on

spillovers among the Chinese and U.S. stock sectors. They display that such event amplifies the risk spillovers for different markets during 03/2020-04/2020. Laborda and Olmo (2021) report that the banking sector seems to be an essential shock transmitter to the rest of the economy. Tabak *et al.* (2022) analyze the impact of the Covid-19 pandemic on changes in the forms and intensity of banking sector connections across various countries. They display that the changes in the classification of receiving and transmitting spillover during the Covid-19 pandemic. They also show interesting acquaintances about systemic integration among banking markets in different countries, particularly during tremendous times. Foglia *et al.* (2022) investigate the volatility connectedness of banking sector in the Eurozone during the period 2005-2020. They report that thirty banks are increasingly interrelated. They also reveal the high effect of Covid-19 pandemic on the volatility dynamics. They afterwards display that small-medium banks play a substantial role in the contagion effect. By using Dynamic Factor Model (DFM) with time-varying loading parameters and stochastic volatility, Kapinos *et al.* (2022) to develop a new measure of comovement in the banking sector which takes into consideration the dynamic nature of interlinkages in the net chargeoffs (NCO) and return on assets (ROA) among banks. They show that the degree of comovement in NCO and ROA peaked during the 2009 financial crisis, indicating a substantial increase in sector-wide stress. Shabir *et al.* (2023) analyze the impact of Covid-19 pandemic on the stability and performance of the banking sectors in 106 countries during the period 2016 Q1-2121 Q2. They indicate that the advent of Covid-19 pandemic has substantially lowered bank stability and performance. They also report that the negative effect of Covid-19 pandemic is related to the features of the market and bank framework.

With the outbreak of the recent bank crisis, many researchers have endeavored the impact of SVB on national stock markets and cross-border linkages. For instance, Aharon *et al.* (2023) analyzes the effect of the SVB collapse on the financial markets. Based on an event study, they show that stock markets responded negatively to the SVB collapse. They also display that stock markets in Latin America, Europe and the Middle East and Africa experienced a substantial and negative reaction on the day of the event. Such impact spent in the aftermath of the SVB collapse. Yousaf *et al.* (2023) analyze the impact of the SVB bankruptcy on financial markets. They display that abnormal returns seem to be negative and significant for US equities, global banks, Bitcoin and GCC equities. Nevertheless, abnormal returns seem to be insignificant for most metals, fiat currencies and energy markets. Akhtaruzzaman *et al.* (2023) examine if the SVB collapse can catalyze financial contagion in India, Brazil, South Africa and the G7 countries. They report that contagion seems to be well-documented within global banks but lower in other areas. They also show that the contagion is short-lived, being most widespread during the week following the SVB failure. Pandey *et al.* (2023) investigate the effect of SVB collapse on financial markets using an event study. They show that the collapse triggered uncertainty and panic, implying substantial and negative returns. The level of the effect is well-documented within developed marks due to the greater level of interdependence and integration with the global economy, along with significant and high abnormal volatility. They also display the effect of the SVB collapse seems not similar among countries.

Yousaf *et al.* (2023) analyze the potential effect of the SVB collapse on US market sectors. They report substantial and negative abnormal returns on the event date uniquely for the real estate, materials and financial sectors. They show that the most substantial effect is recorded for the financial sector. Yadav *et al.* (2023) analyze the effect of SVB fall on stock indices during the period 06/09/2022-22/03/2023. They show that the significant sell-off of

stocks could explain such movement. They also report that the SVB failure significantly affect stock markets, coupled with contagion effects spreading among markets. Azmi *et al.* (2023) analyze the effect of SVB collapse on global assets. They report that no substantial reaction is detected, except for US Treasury Bills and gold. They also display little evidence of spillover/reputation contagion from the SVB fall to other asset classes. Dosumu *et al.* (2023) investigate how social media increases the effect on bank collapse on financial markets. They show that the important role of social media which contributes to the immediate, significant and negative impact of the bank crisis on stock markets. They also report a relevant spillover effect of the bank crisis on G7 and European economies. Nevertheless, no significant effect is documented for markets in Asia and Africa.

Aharon *et al.* (2023) examine the possible impacts on different financial markets of a banking shock by exploring the recent collapse of SVB and its repercussions on technological and banking companies in the Europe, China and US and its impacts on gold, oil and cryptocurrency markets. Using event study method, the empirical results display that assets (e.g. gold, cryptocurrencies and oil) show positive returns, indicating that investors search for refuge in these perceived safe-haven assets. They also display that the SVB's financial distress has a significant impact on the stocks of banking firms in Europe and US whereas it has a positive effect on the stocks of technology firms in these regions. Mehdian *et al.* (2024) show that the reactions of financial markets to the failure of some banks seem to be mixed. The banks' collapses lead to stronger market volatilities than positive news for Dow Jones Equity Real Estate Investment Trust Index and Bitcoin. Galati and Capalbo (2024) use BEKK model to analyze contagion effects among digital assets during the SVB collapse. The results show that the presence of contagion effects among Bitcoin and major stablecoins. Sarmiento (2024) assesses how the market stress is linked to the failure of one of the most interconnected NBFIs in emerging market economy impacted the availability and pricing of unsecured interbank funding. The findings display that the market stress conducted to a reallocation of money mutual funds deposits within the banking sector, which impacted the banks' liquidity provision in the unsecured interbank market.

3. METHODOLOGY

To investigate the effect of the momentous events such as the collapse of SVB bank on the interdependence of bank stocks of different countries with US bank stocks, this article uses the wavelet coherency (WTC) and wavelet local multiple correlation (WLMC) approaches.

According to the advantages of wavelet transforms, techniques such as cross-wavelet analysis (CWT) and wavelet coherence (WTC) have emerged as powerful tools to investigate the interdependence of financial indices (Gençay *et al.*, 2001).

We use WTC and phase analysis to examine the interdependence and causality of two indices in the time-frequency domain. Furthermore, we use WLMC to investigate the multiple correlations between the US banking stock and G7 and BRIC banking stock indices at different time horizons. One of the most advantages of using the wavelet approach in financial analysis is to examine the correlation at the time and scale. Although econometric methods such as the DCC-GARCH also show a correlation in the time, but they are not able to analyze the correlation at scale.

In the following parts, we briefly illustrate WTC and WLMC concepts.

3.1 Wavelet Coherency (WTC)

The co-movement between two series over time and frequencies is measured by using coherence. Wavelet coherence coefficient defines as follows (Torrence and Compo, 1998; Torrence and Webster, 1999):

$$R_t^2(s) = \frac{|S(S^{-1}W_t^{AB}(s))|^2}{S\left|\left(S^{-1}\left|W_t^A(s)\right)\right|^2 S\left|\left(S^{-1}|W_t^B(s)\right)\right|^2|} \quad (1)$$

In equation (1), S is a smoothing operator for both time and scale. $R_t^2(s)$ is similar to the correlation coefficient. Since its value is positive, the values close to 0 show weak dependence, and the values close to 1 reveal strong dependence. However, this coefficient does not indicate the direction of causality. To illustrate the direction of causality and negative or positive correlation, we use wavelet coherence phase difference analysis. The wavelet coherence phase can be expressed as equation (2):

$$\Phi_{xy}(\mathrm{s}) = \tan^{-1}\left(\frac{I\left\{S\left(S^{-1}W_t^{AB}(s)\right)\right\}}{R\left\{S\left(S^{-1}W_t^{AB}(s)\right)\right\}}\right) \quad (2)$$

where I and R show the imaginary and real parts of the smooth power spectrum, respectively.

3.2. Wavelet Local Multiple Correlation (WLMC)

WLMC is an extended wavelet approach in which dynamic correlations of multivariate are investigated. In other words, this type of multiple correlation is variated over time. Fernández-Macho (2018) introduced the estimated WLMC:

$$\tilde{\rho}_{X,s}(\lambda_j) = \mathrm{corr}\,(\theta(t-s)^{\frac{1}{2}}w_{ijt}, \theta(t-s)^{\frac{1}{2}}\widehat{w}_{ijt}) = \frac{\mathrm{cov}\,(\theta(t-s)^{\frac{1}{2}}w_{ijt}, \theta(t-s)^{\frac{1}{2}}\widehat{w}_{ijt})}{\sqrt{\mathrm{Var}(\theta(t-s)^{\frac{1}{2}}w_{ijt})\mathrm{Var}(t-s)^{\frac{1}{2}}\widehat{w}_{ijt})}} \quad (3)$$

where $s = 1, \ldots, T$ and $\theta(\cdot)$ is a moving average weight function. In this research, the Gaussian function considered in Fernandez's article is used.

4. DATA AND DESCRIPTIVE STATISTICS

In this article, KBW Bank (BKX), S&P/TSX Canadian Financials, FTSE 350 Banks (FTNMX301010), CAC Financials (FRFIN), DAX Banks (CXPBX), FTSE Italia All-Share Banks (FTITLMS3010), Nikkei 500 Banking (NBKS), Financials (IFNC), MOEX Financials (MOEXFN), Nifty Bank (NSEBANK), and FTSE China A 600 - Banks (FTXIN4301010) data are used during the period from 1/1/2016 to 4/28/2023, containing a total of 1890 available daily observations. The return for the banking stock index (R_{it}) is defined as $R_{it} = \frac{P_{it}-P_{it-1}}{P_{it-1}}$, where P_{it} and P_{it-1} represent the price of the bank stock index i at time t, and time $t-1$, respectively. Annex 1 indicates plots on these returns.

Table no. 1 – Descriptive statistics

Index Code	MAX	MIN	Mean	Std. Dev	Kurtosis	Skewness	JB	ADF
KBW Bank (BKX)	13.82	-17.67	0.0046	1.93	11.393*** (0.000)	-0.547*** (0.000)	8422.023*** (0.000)	-45.080*** (0.000)
S&P/TSX Canadian Financials	13.93	-13.71	0.019	1.14	43.704*** (0.000)	-0.689*** (0.000)	122924.069*** (0.000)	-42.474 *** (0.000)
FTSE 350 Banks (FTNMX301010)	11.54	-11.12	-0.0026	1.61	7.042*** (0.000)	-0.220*** (0.000)	3200.292*** (0.000)	-42.107 *** (0.000)
CAC Financials (FRFIN)	11.17	-15.11	0.006	1.52	15.765*** (0.000)	-0.954*** (0.000)	16212.848*** (0.000)	-38.634*** (0.000)
DAX Banks (CXPBX)	11.99	-20.38	-0.014	2.43	6.892*** (0.000)	-0.690*** (0.000)	3176.077*** (0.000)	-39.736*** (0.000)
FTSE Italia All Share Banks (FTITLMS3010)	11.03	-24.94	-0.013	2.22	9.952*** (0.000)	-1.044*** (0.000)	6647.654*** (0.000)	-40.825*** (0.000)
Nikkei 500 Banking (NBKS)	7.76	-8.36	-0.018	1.5	2.119*** (0.000)	-0.230*** (0.000)	302.210*** (0.000)	-37.092*** (0.000)
Financials (IFNC)	12.36	-14.25	0.05	1.84	9.155*** (0.000)	-0.615*** (0.000)	5486.049*** (0.000)	-42.520*** (0.000)
MOEX Financials (MOEXFN)	12.29	-24.66	0.017	1.67	40.470*** (0.000)	-3.149*** (0.000)	107847.398*** (0.000)	-36.645 *** (0.000)
Nifty Bank (NSEBANK)	7.98	-18.31	0.049	1.44	19.630*** (0.000)	-1.324*** (0.000)	25223.573*** (0.000)	-42.072*** (0.000)
FTSE China A 600 - Banks (FTXIN4301010)	44.62	-65.35	0.002	2.19	440.551*** (0.000)	-8.536*** (0.000)	12496773.861*** (0.000)	-50.621*** (0.000)

Notes: *** indicates significance at 1%; Std. Dev and JB denotes standard deviation and Jarque-Bera test, respectively. ADF denotes Augmented Dickey and (1979).

Table no. 1 displays the descriptive statistics of the returns of bank stock markets in G7 and BRIC countries. The average returns of all indicators except the bank stock in the UK, Germany, Italy, and Japan are all positive. This reveals that in these countries, on average, the returns of banking stocks have been positive. The highest and lowest returns are related to the China index. Also, based on the standard error deviation, the highest and lowest dispersion are assigned to Germany and Canada indices, respectively. All the series display a leptokurtic distribution and are negatively skewed. More precisely, all the distributions are characterized by a longer tail on the distribution's left part. The high values of kurtosis indicator indicate heavier tails and reveal the impact of extreme events. The FTSE China A 600-Banks index has the highest kurtosis and skewness, indicating the presence of large shocks. In contrast, NBKS has the lowest kurtosis and skewness compared to other indices, indicating that it is less volatile. The statistical properties of these time series, such as high kurtosis, skewness, and non-normal distribution, can significantly influence the analysis and the selection of appropriate methods. Therefore, it is crucial to employ a method that does not rely on assumptions about the underlying distribution of data. Wavelet analysis, which is free from distributional assumptions, is particularly effective in managing the inherent statistical

complexities. This approach is well-suited for analyzing financial data, which may exhibit non-linear fluctuations or extreme shocks.

Table no. 1 afterwards presents the estimation results from applying Augmented Dickey-Fuller (ADF) unit root test on different time series. One might reject the null hypothesis of a unit root. This finding is also confirmed by accepting the null hypothesis of stationary process.

Table no. 2 – Correlation between bank stock indices in G7 and BRIC countries

		US	UK	CA	FR	GE	IT	JP	CH	RU	IN	BR
G7	**US**	1										
	UK	0.59	1									
	CA	0.76	0.54	1								
	FR	0.65	0.80	0.63	1							
	GE	0.57	0.74	0.54	0.81	1						
	IT	0.53	0.68	0.50	0.82	0.78	1					
	JP	0.17	0.26	0.20	0.27	0.25	0.20	1				
BRIC	**CH**	0.04	0.09	0.06	0.8	0.06	0.05	0.08	1			
	RU	0.23	0.31	0.30	0.36	0.30	0.30	0.08	-0.001	1		
	IN	0.33	0.35	0.40	0.43	0.31	0.31	0.18	0.09	0.26	1	
	BR	0.44	0.31	0.49	0.37	0.30	0.30	0.09	0.03	0.18	0.23	1

Table no. 2 presents the correlation between the bank stock indices. According to Table no. 2, it can be observed that the highest and the least correlations are associated with France-Italy and China-Russia, respectively. Also, in G7 countries, Canada and Japan have the highest and the least correlation with the US bank stock index, respectively. Moreover, in BRIC countries, there are the highest and the least correlation with the US bank stock in Brazil and China, respectively.

5. RESULTS AND INTERPRETATIONS

This section investigates the interdependence and causality between the banking stock indices in BRIC and G7 counties with the US bank stock index, at different time scales using wavelet coherency and phase difference. In this section, we use coherency wavelet heat figures. The horizontal and vertical axis represent time and scale, respectively. Also, the color shows the amplitude of coherency. According to the vertical bar on the right-hand axis, the warmer red color represents a stronger correlation. In contrast, the blue color represents a region with a lower correlation. A black line that is drawn around some regions shows the intensity and significance of the correlation. The periods are 4, 16, 64, and 256, daily. The value of wavelet coherence is always positive. The value of wavelet coherence is always positive. So, we couldn't distinguish between positive and negative co-movements without employing additional techniques such as the phase difference approach. By analyzing the phase difference, one can gain a better understanding of the nature of the relationship between the variables and determine which one is causing changes in the other. In the phase difference approach, the direction of causality between two variables is represented by arrows. When the arrows are pointing to the right (→) or left (←), it indicates that the two variables behave in phase or anti-phase, respectively. On the other hand, when the arrows are pointing (↑), (↗), or

(↙), it signifies that the first variable is leading. Conversely, when the arrows are pointing (↓), (↖), or (↘), it shows that the second variable is leading.

Our results can be summarized across three sections as follows.

5.1 The interdependence between US bank stock return and G7 bank stock returns

Figure no. 1 presents the correlation between the US banking stock return and six banking stock returns in G7 region. The most interdependence exists between the US banking stock and Canadian banking stock. Also, the interdependence between the US banking stock and Japanese banking stock is lower than in other countries. Panels a, b, and c (Figure no. 1) show the co-movement between the USA banking stock and the UK, Canadian, and France banking stocks. Based on this crux, there are stronger correlations in these markets with the US. The phase difference analyses show that they are in phase. In addition, in the short term, the co-movement between US-Canada is higher after the Covid-19 pandemic. Such findings are in line with those of Baranova *et al.* (2022) who showed that UK and Canadian banking stock indices have a relative correlation with the USA banking stocks. The degree of correlation between the USA banking stock and the UK, Canadian, and France banking stocks makes diversification benefits between such assets practically impossible, especially during the post-Covid-19 pandemic. This implies that investors and portfolio managers cannot find hedge, safe-haven benefits and diversification benefits when including such assets together.

As shown in Figure no. 1, at the beginning of the period, the correlation between bank stock indices in the G7 countries and the United States increased. In this period, the correlation between bank stock indices in the G7 countries and the USA increased. The German banking crisis and issues related to non-performing loans in Italy had a great impact on the European stock markets during this period. As a matter of fact, the International Monetary Fund warned about the possible future uncertainty of global financial stability and risk spillover among the 28 banks in the global systemically important banks (IMF, 2016). Although the correlation between the banking indices of the investigated countries and the United States has relatively decreased during the years 2017 to 2018, with the formation of the Turkish currency crisis and then the Covid-19 pandemic, this relationship has been relatively intensified. Overall, the Covid19-pandemic is the one of most factors that caused the interdependence between markets after 2020. Even though, after 2021 these correlations were declining. After 2022, these relationships are increasing. Ukraine war and bank crises such as the SVB collapse are the significant factors that cause this increase.

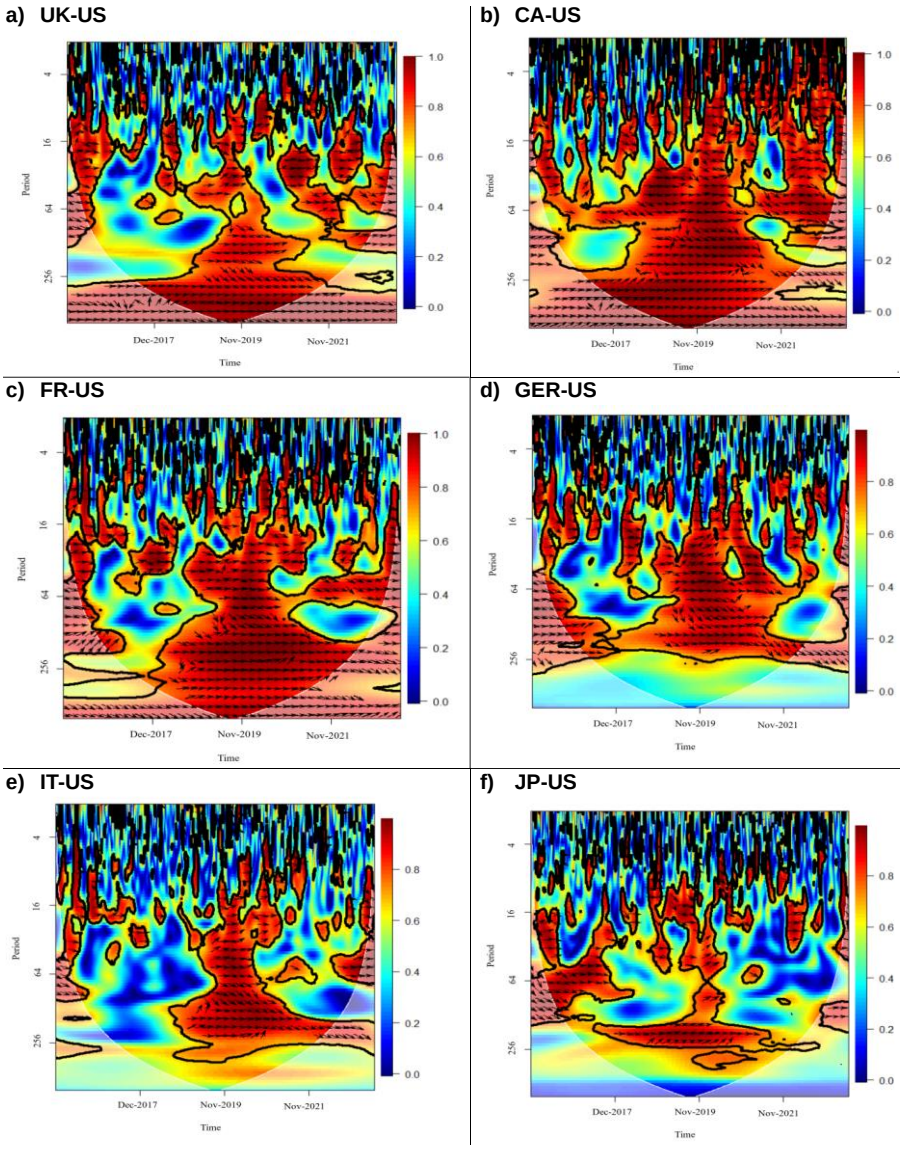

Figure no. 1 – The interdependence between US bank stock return and G7 bank stock returns, using wavelet coherency

5.2 The interdependence between US bank stock return and BRIC bank stock returns

Figure no. 2 presents a wavelet coherency between the US banking sector stock returns and the four BRIC country's banking sector stock returns. In Figure no. 2, the Indian banking stock sector has the highest correlation with the US banking stock. This correlation is higher in the long term. In general, the correlation between the banking stock sector of BRIC

countries and the US banking stock sector has increased in the medium term since mid-2018. This correlation has been higher in Brazil, India, and Russia. However, since 2021, this correlation has declined in BRIC countries. The results of the phase difference analysis in Figure no. 2 show that the returns are generally in-phase. It also reveals that US banking stock drives the co-movements of Brazilian and Indian banking stocks in the long term. Such finding displays that investors cannot gain diversification benefits from holding US banking stock at long term. Specifically, most right-pointing arrows in the long term are upward after 2018. On the other hand, Figure no. 2 clearly shows that the co-movement between US banking stock and BRIC countries often is little in the short-term. As such, BRIC banking stock markets can provide rewarding grounds for investors in short-term.

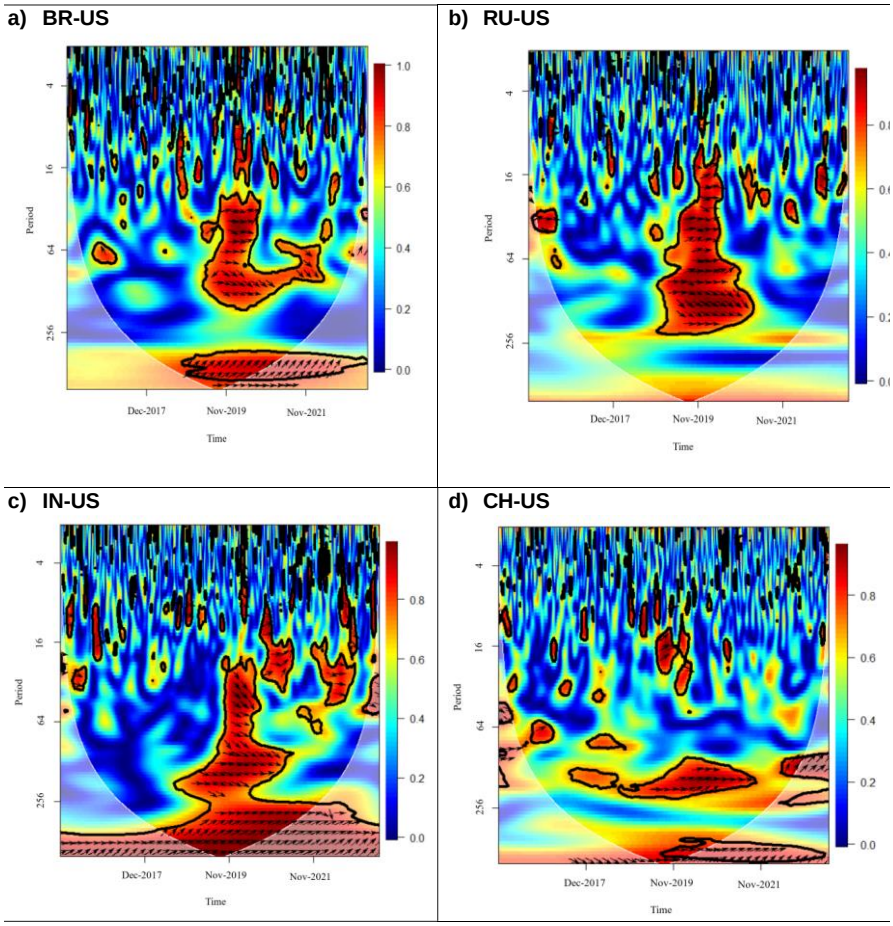

Figure no. 2 – The interdependence between US bank stock return and BRIC bank stock returns, using wavelet coherency

Comparing Figure no. 1 and Figure no. 2 reveals that the interdependence between the banking stock market in G7 and USA is more important than the BRIC and USA. The banking

crises before 2018 or after 2021 increased the correlation between markets in G7 countries but this correlation declined in BRIC countries. It seems that the most important factor that has caused greater correlation between the American banks index and the BRIC countries is the Covid-19 pandemic crisis. It is worth noting that investors cannot gain diversification benefits from holding of such assets and develop effective risk management strategies.

5.3 The interdependence between US- BRIC and US-G7 bank stock market: A comparative analysis

This section examines the wavelet local multiple correlations (WLMC) between G7 and BRICS countries' banking stock with the US. Figure no. 3 and Figure no. 4 illustrate the WLMC for the G7 and BRIC countries respectively. As mentioned earlier, the vertical bar on the right side of the figure shows the colors that represent the correlation of the markets. In Figure no. 3, the range of this correlation is determined from 80 to 100 percent. So, the blue color indicates 80, and the red color indicates the highest correlation. According to Figure no. 3, the correlation between bank stock indices in the G7 countries and the United States is high during the period under study. However, this correlation has increased at times. In other words, this interdependence seems to be intensified during crises, including the banking crisis of 2016, the Covid-19 pandemic, the war in Ukraine, and the recent economic and banking problems in 2023 such as the bankruptcy of SVB.

These findings align with the bi-directional analysis in Figure no. 1, emphasizing that crises amplify correlations between banking stocks in G7 countries. Similarly, the results show that the correlation between the G7 countries' bank stock indices and the United States is also high. This increasing interdependence significantly reduces investors' ability to achieve diversification benefits when constructing portfolios that include these assets.

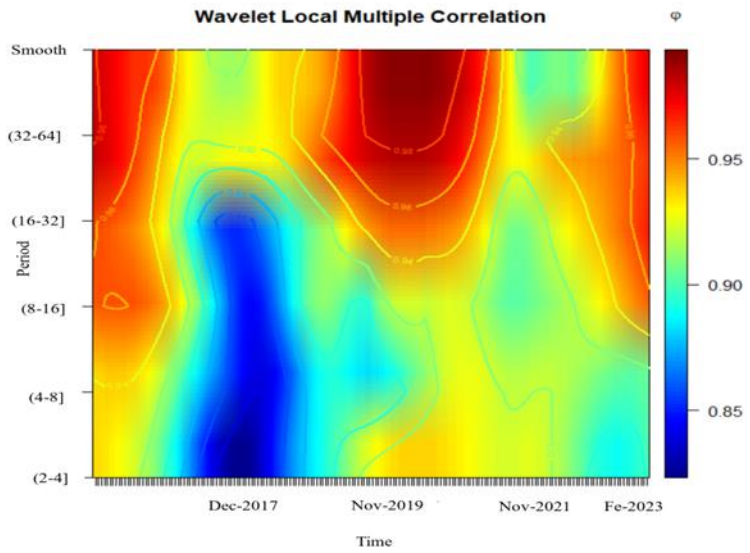

Figure no. 3 – The interdependence between US-G7 bank stock market using WLMC

In Figure no. 4, the range of the correlation is determined from 30 to 100 percent. The blue color represents a correlation of 30 percent or less, while the red color indicates the highest correlation of 100 percent. As shown in Figure no. 4, the correlation of banking stocks in BRIC countries with the United States has increased in all frequencies during the Covid-19 pandemic. Comparing Figure no. 2 and Figure no. 4 shows that the correlation between the US banking stock market and the BRIC countries has increased significantly during 2019 and 2020, especially in the medium and long term. Furthermore, a comparison of Figure no. 3 and Figure no. 4 reveals that the correlation between the banking stock markets of G7 countries and the United States is higher than that of the BRIC countries.

During the COVID-19 pandemic, the correlation pattern between the BRIC countries and the United States is similar to that of the G7 countries. However, the correlation between the G7 countries and the United States is more significant during 2016 and 2023. The beginning of the analyzed period coincides with the onset of the banking crisis in the European Union. Additionally, it appears that the war in Ukraine and the SVB collapse have further intensified the interdependence of the banking stock markets in the G7 countries with the United States. In contrast, the banking crises of 2016, the recent banking crisis, and the war in Ukraine have had a lesser impact on the correlation of the banking stock markets in the BRIC countries. This suggests that BRIC countries can attract the attention of investors seeking to diversify their portfolios. Therefore, they can be considered a safe investment haven at the international level, particularly during periods of banking crises or political uncertainty.

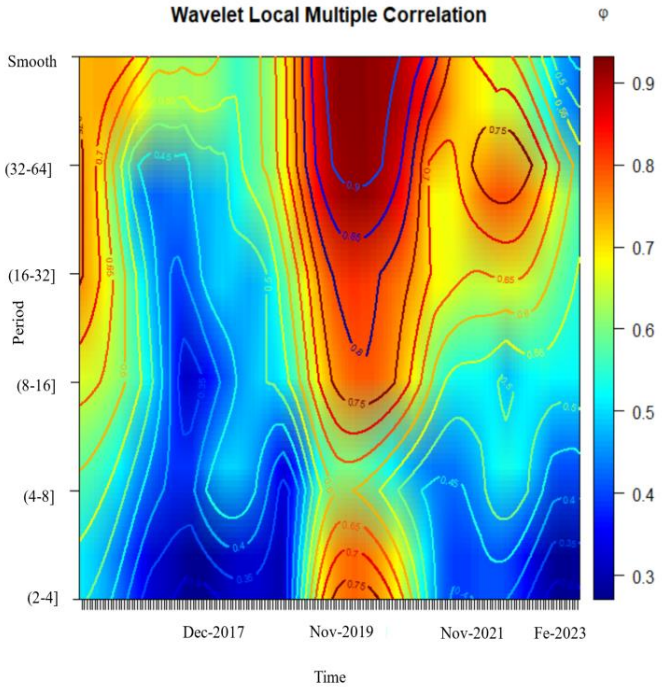

Figure no. 4 – The interdependence between US-BRIC bank stock market, using WLMC

6. CONCLUSIONS AND DISCUSSIONS

As mentioned earlier, many researchers have increasingly attempted to investigative the potential impact of bank runs and failures and other unexpected events on the behavior and dynamics of financial markets and cross-border linkages. Most of them report the significant and negative effects of bank crisis on national and international financial markets. With the outbreak of Silicon Valley Bank fiasco, the debate of its impact on global stock markets has increasingly revived by analyzing the potential ramifications for stock dynamics. In this regard, Pandey *et al.* (2023), among others, focus on the short-lived or immediate of such event on global asset classes using the event study event approach. Based on this crux, we attempt to analyze the structure and dynamics of connections between bank stock indices of different countries in G7 and BRICS regions during the outbreak of tremendous events. To this end, we use the wavelet coherency (WTC) and wavelet local multiple correlation (WLMC) approaches during the period from 1/1/2016 to 4/28/2023. Such approaches enable to analyze and better apprehend the nature and duration of the nexus between asset classes. This could help to better emphasize the behavior and dynamics of such nexus with the advent of exceedingly adverse and unexpected events such as the Covid-19 pandemic. Not only that, the WLMC approach seems to be useful statistical and computational method which could assess correlation across multivariate, non-stationary, financial time series (Fernández-Macho, 2018).

Overall, analyzing the dynamic time-frequency connectedness of US bank stocks and bank stocks in different regions in both bivariate and multivariate framework reveals interesting findings. First, the connection among assets tends to change both short- and long-term. For instance, the empirical results show that US bank stock drives the comovements of the Indian and Brazilian banking stocks in the long-term. Second, some cross-correlations become stronger and higher due to the outbreak of SVB collapse and the Ukraine-Russia war. In this regard, it is noteworthy that the effect of the SVB fiasco is not similar and uniform among countries and regions. For example, such adverse event seems to have a lesser effect on the correlation of the banking stock markets of the BRIC countries. Such result is consistent with those of Pandey *et al.* (2023) who explain it by the difference in banking system development and financial stability. The nature of tremendous events has an incredibly impact on the asymmetric dynamics of comovements among assets. Our findings also corroborate those of Yadav *et al.* (2023) which report the contagion and spillover effects disseminating across borders. The bi- and multi- wavelet analysis clearly also shows that relevant comovements across different banking sector stocks and such connections vary over time due to unexpected events such as the Covid-19 pandemic. The intensity and level of comovement seem to relate not only to the geography of country but also the resilience/fragility of banking sector to the advent of adverse events. Such findings seem to corroborate those of Baumöhl *et al.* (2022) who show that connections across seem to be affected by adverse events.

Our empirical findings could offer insightful implications for policymakers and portfolio managers. The effects of unanticipated shocks on financial markets and particularly banking system stocks can spill over and could vary substantially among countries/regions according to the market microstructure and banking system development. In this respect, financial markets in some countries can attract the attention of investors to diversify their portfolios. Therefore, they can be considered a safe investment haven at the international level, especially in a banking crisis or political uncertainty. Interestingly enough, the behavior and degree of correlation among different banking stocks in the G7 and BRIC countries both frequency and

time domains provide insightful signals to undertake portfolio rebalancing in a timely fashion to attain safe-haven, diversification and hedging benefits. Such findings also invite stakeholders to re-consider the spatial spillover transmission effects of stressful events when investigating the markets dynamics in sector perspective. In particular, investors could be aware of the idiosyncratic shocks related to such events across different markets and regions and the potential arbitrage opportunities which could last in the banking stock markets in order to guarantee relevant trading decisions and adjust portfolio allocations among different investment horizons. This also invites policymakers to strategically think about the (dis)advantages of such connections to effectively regulate the banking ecosystem to alleviate the contingency of price gouging, which could influence the decision-making of investors. Further studies could extend our work by incorporating other developing markets to analyze the pattern of potential connections among them.

Declaration of competing interest

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

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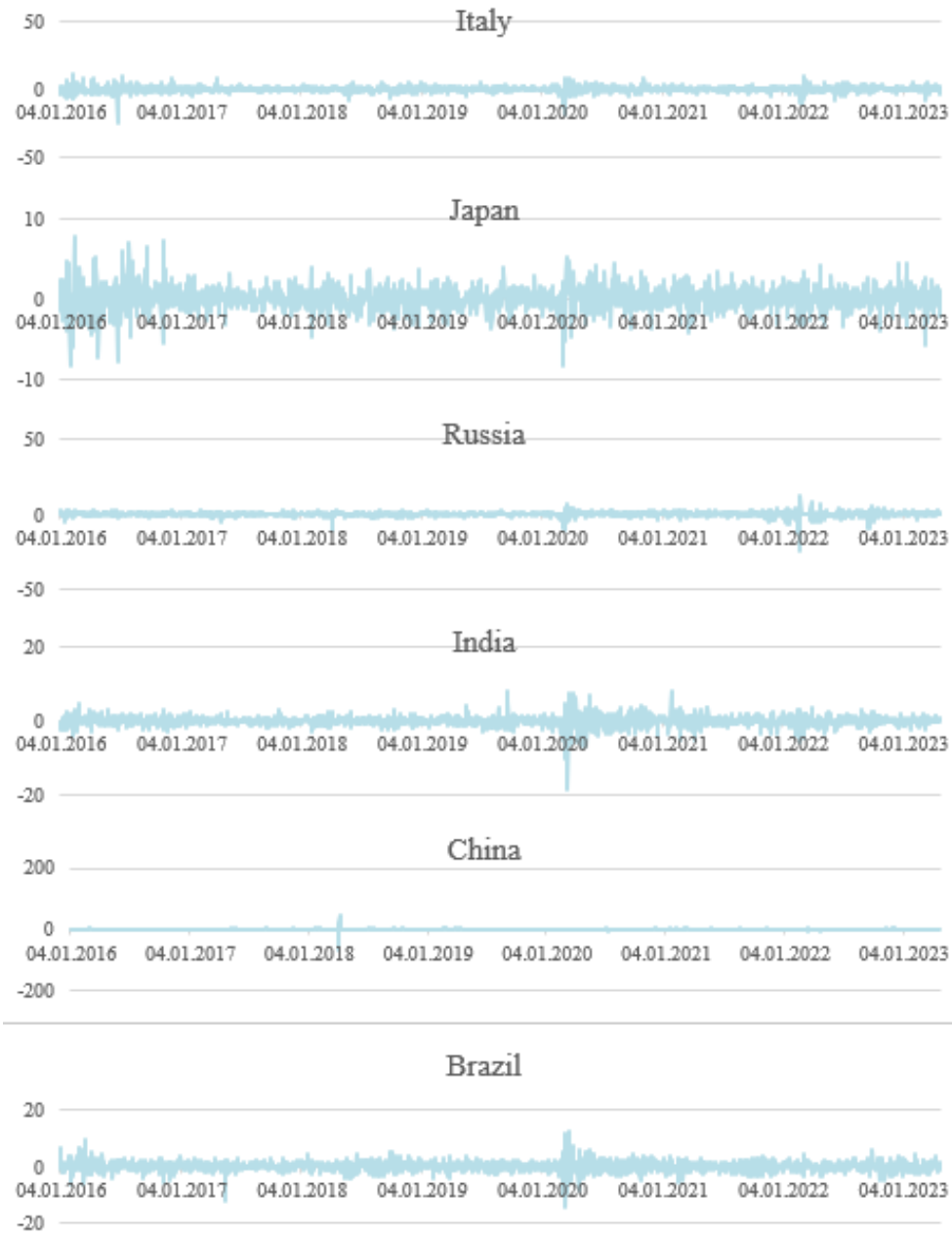
ANNEX 1

Plots of returns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Russia
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India
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China
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Brazil
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