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GCG
The Journal *of* Globalization, Competitiveness, and Governability

Connectedness Between Regional Financial Markets: Evidence from Covid-19 and Russia-Ukraine Conflict

AREA: 1
TYPE: Application

Conectividad Entre los Mercados Financieros Regionales: Evidencia del Covid-19 y el Conflicto Rusia-Ucrania
Conectividade Entre os Mercados Financeiros Regionais: Dados da Covid-19 e do Conflito Rússia-Ucrânia

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The paper studies the connectedness of seven regional financial markets since 2018 to 2023 through a TVP-VAR model. The time period selected allow us to study the effects of the connectedness before and after international shocks such as the COVID-19 and the Russian-Ukraine war. Results show that these markets are highly connected but results are heterogenous according to the international shock. During the COVID-19 pandemic, the worldwide uncertainty triggered greater interconnectedness; whereas, the war conflict does not have significant implications, but it did increase the sensitivity of regional markets close to the armed conflict. These results are an important tool in risk management and public policy

El trabajo estudia la conectividad de siete mercados financieros regionales desde 2018 hasta 2023 a través de un modelo TVP-VAR. El periodo de tiempo seleccionado nos permite estudiar los efectos de la conectividad antes y después de shocks internacionales como el COVID-19 y la guerra ruso-ucraniana. Los resultados muestran que estos mercados están muy conectados, pero los resultados son heterogéneos según el choque internacional. Durante la pandemia del COVID-19, la incertidumbre mundial provocó una mayor interconexión; mientras que el conflicto bélico no tiene implicaciones significativas, pero sí aumentó la sensibilidad de los mercados regionales cercanos al conflicto armado. Estos resultados constituyen una herramienta importante para la gestión de riesgos y las políticas públicas.

O artigo estuda a conetividade de sete mercados financeiros regionais de 2018 a 2023 através de um modelo TVP-VAR. O período de tempo selecionado permite-nos estudar os efeitos da conetividade antes e depois de choques internacionais como a COVID-19 e a guerra russo-ucraniana. Os resultados mostram que estes mercados estão altamente ligados, mas os resultados são heterogéneos, dependendo do choque internacional. Durante a pandemia de COVID-19, a incerteza global levou a uma maior interligação; enquanto o conflito bélico não tem implicações significativas, mas aumentou a sensibilidade dos mercados regionais próximos do conflito armado. Estes resultados constituem uma ferramenta importante para a gestão do risco e para as políticas públicas.

DOI	Received	Accepted
10.58416/GCG.2024.V18.N1.05	12.08.2023	12.09.2023

GCG
The Journal of Globalization, Competitiveness, and Governability

1. Introduction

In the last five years, humanity has faced two major events that have caused a significant number of global repercussions: the COVID-19 pandemic and the Russian-Ukraine war conflict. Since the beginning of the COVID-19 pandemic in December 2019, financial markets and global health was affected. The effects of the global pandemic on financial and assets markets have been studied from various perspectives; for instance: oil (Chatziantoniou, Gabauer, & Perez de Gracia, 2022), precious metals (Yıldırım, Esen, & Ertuğrul, 2022), financial markets (Muñoz-Henríquez & Gálvez-Gamboa, 2021), exchange rate (Hung & Vinh, 2023), among others.

The Russian-Ukraine war conflict has been less well documented in the literature due to its recent occurrence. Recent works shows that this conflict has had negative effects on commodity market volatility (Fang & Shao, 2022) and on the global food supply chain (Jagtap et al., 2022). (Umar, Polat, Choi, & Teplova, 2022) has shown that Russian bonds are the main transmitters of shocks to international markets during the event. These effects are mainly triggered by Russia's role in the global energy market, the European bond market and the size of its economy.

Both, the COVID-19 pandemic and the Russia-Ukraine war conflict are a challenge for global financial markets due to the connectivity that exists between regional and global markets. An important part of the literature examines the connectivity between financial markets through the Spillover Index developed by Diebold & Yilmaz (2009, 2012, 2014). For example, the study made by (Ben Amar, Bélaïd, Ben Youssef, & Guesmi, 2021) examines the connectivity of regional markets during the COVID-19 period (European, Latin American, North American, Asian, Pacific and Gulf Cooperation Council markets), identifying the reaction of markets to the uncertainty caused by the pandemic and the disconnection of Latin American markets from global financial markets. These results differ from those presented by (Muñoz & Gálvez-Gamboa, 2022) in calculating the frequency-dominated connectivity of Latin American markets with the US market, identifying the short-term spillover effect when studying returns and the long-term spillover effect when analyzing volatilities.

Regarding the war conflict, (Umar et al., 2022) use a TVP-VAR methodology to study the effect of the war conflict; so that, they calculate a measure of dynamic connectivity with the Russian financial market, European financial markets and the global commodities market. They identify that when the conflict occurs the connectivity between the markets changes and the conflict affects the connectivity of the returns (volatility) in the short term (long term). Similarly, (Fang & Shao, 2022) using a spillover measure of volatility risk identify that the war conflict increases the volatility of agricultural, metal, and energy markets, affecting them through financial and economic channels. Other studies, such as that of (Beraich, Amzile, Laamire, Zirari, & Fadali, 2022) show volatility transmission between American, European and Chinese financial markets, demonstrating that volatility increased during the war conflict, but to a lesser extent than during the COVID-19 pandemic. These results are consistent with the findings of (Babar, Ahmad, & Yousaf, 2023) when studying the connectivity between agricultural commodities and emerging stock markets.

Keywords
Regional Financial Markets, TVP-VAR, Connectedness

Palabras Clave
Mercados Financieros Regionales, TVP-VAR, Conectividad.

Palavras-chave
Mercados financeiros regionais, TVP-VAR, conetividade.

JEL Codes
C10, G15

Therefore, considering both international events and the results of different research that identify a spillover effect, we wonder if the connectedness of world markets was equally affected by Covid-19 and the subsequent Russia-Ukraine war. To answer this question, we investigated the connectedness between developed (European, North American and Pacific) and emerging (Asian, GCC, Latin American and European) regional financial markets, calculating a Connectedness Index through a TVP-VAR methodology.

Our work contributes to the literature investigating the connectedness between financial markets before and during periods of turbulence, particularly focusing on the period comprising COVID-19 and the Russia-Ukraine war. Moreover, the paper provides original results that contribute to the debate in two ways. First, by identifying high connectivity between developed and emerging regional markets and how this varies when periods of turbulence are considered. Second, by identifying those regional markets that are transmitters or receivers of connectivity at the aggregate level and at the disaggregated level considering periods of shocks.

The article is structured as follows: Section 2, presents the methodology used, Section 3, shows the estimation results considering the full sample and the sub-samples considering the events. Finally, Section 4 provides the conclusions and implications.

2. Methodology

We use the approach developed by Antonakakis, Chatziantoniou, & Gabauer (2020) as an extension to the Spillover Index proposed by Diebold & Yilmaz (2009, 2012, 2014) to study the connectedness between different markets and/or assets. The authors propose a dynamic connectivity based on time-varying parameters of an autoregressive vector (TVP-VAR). The particularity of this methodology is that it overcomes the arbitrariness of the moving windows of the base model, and thus, it avoids the loss of observations. Thus, a TVP-VAR model with a lag of order one can be defined as follows:

$$x_t = \Phi_t x_{t-1} + \epsilon_t \qquad \epsilon_t \sim N(0, S_t) \qquad (1)$$

$$vec(\Phi_t) = vec(\Phi_{t-1}) + \xi_t \qquad \xi_t \sim N(0, \Xi_t) \qquad (2)$$

Where x_t, ϵ_t and ξ_t y a vector ***(N x 1)***, and S_t, Φ_t and Ξ_t are matrixes of order ***(N x N)***.

The approach of (Diebold & Yilmaz, 2012) uses time-varying parameters of moving average vectors (TVP - VMA) as the generalized forecast error variance decomposition (GFEVD) of (Koop et al., 1996; Pesaran and Shin, 1998). Thus, using Wold's theorem representation is possible to transform the TVP-VAR into a VMA as:

$$x_t = \sum_{i=1}^{p} \Phi_t x_{t-1} + \epsilon_t = \sum_{j=1}^{\infty} A_{jt} \epsilon_{t-j} + \epsilon_t$$

Therefore, the GFEVD could be expressed as:

$$\varnothing_{ij,t}^{g}(J)=\frac{S_{ii,t}^{-1}\sum_{t=1}^{J-1}\left(\rho_i' A_t S_t \rho_j\right)^2}{\sum_{j=1}^{N}\sum_{t=1}^{J-1}\left(\rho_i A_t S_t A_t' \rho_i'\right)} \qquad \tilde{\varnothing}_{ij,t}^{g}(J)=\frac{\varnothing_{ij,t}^{g}(J)}{\sum_{j=1}^{N}\varnothing_{ij,t}^{g}(J)} \tag{3}$$

Where $\boldsymbol{\rho_t}$ is a vector with a one at position $\boldsymbol{i}$ and zeros at all others positions. By construction $\sum_{j=1}^{N}\tilde{\varnothing}_{ijt}^{N}(J)=1$ and $\sum_{i,j=1}^{N}\sum_{j=1}^{N}\tilde{\varnothing}_{ijt}^{N}(J)=N$. The parameter $\tilde{\varnothing}_{ij,t}^{g}(J)$ represents a directional connectivity loss from market $\boldsymbol{j}$ to market $\boldsymbol{i}$.

Therefore, with the GFEVD it is possible to calculate the connectivity measures proposed by (Diebold & Yılmaz, 2014).

Total Connectedness Index (TCI):

$$C_t(J)=\frac{\sum_{i,j=1,\,j\neq i}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}{\sum_{i,j=1}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}*100=\frac{\sum_{i,j=1,\,j\neq i}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}{N}*100 \tag{4}$$

Total Directional Connectedness to Others (TDCTO):

$$C_{i\rightarrow j,t}(J)=\frac{\sum_{j=1,\,j\neq i}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}{\sum_{j=1}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}*100$$

Total Directional Connectedness from Others (TDCFO):

$$C_{i\leftarrow j,t}(J)=\frac{\sum_{j=1,\,j\neq i}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}{\sum_{i=1}^{N}\tilde{\varnothing}_{ij,t}^{N}(J)}*100$$

Net Total Directional Connectedness (NTDC):

$$C_{i,t}=C_{i\rightarrow j,t}(J)-C_{i\leftarrow j,t}(J)$$

Net Pairwise Directional Connectedness (NPDC):

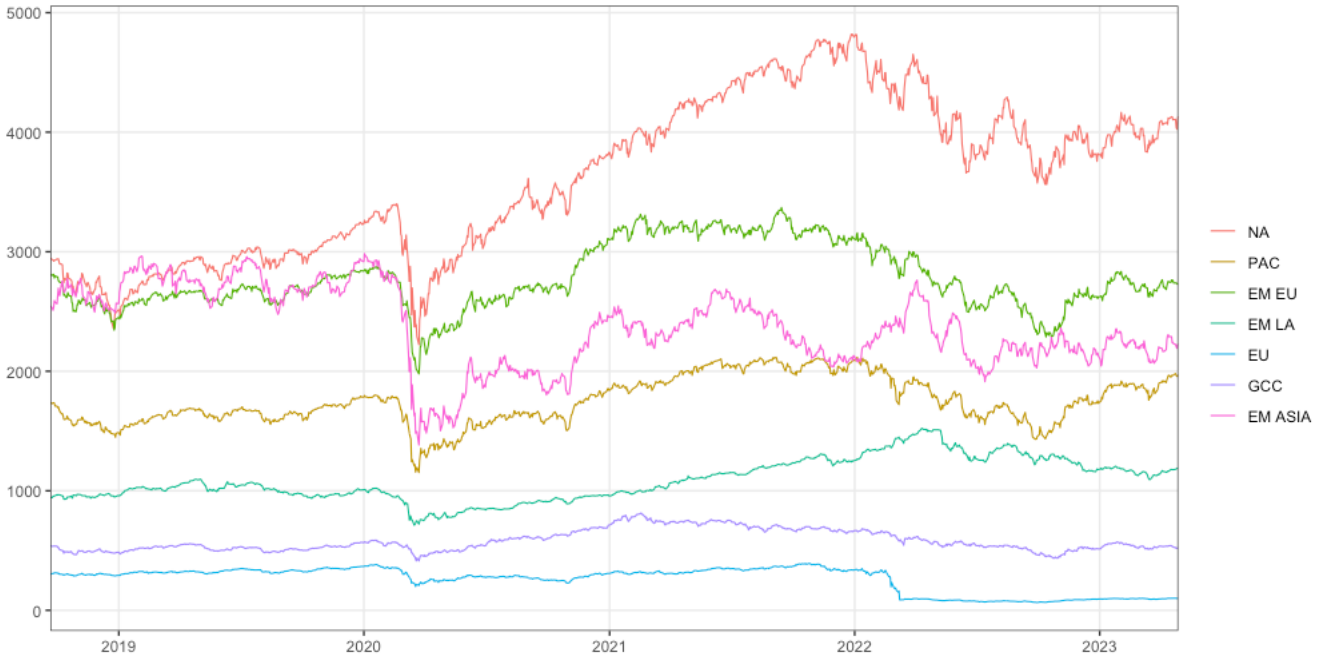
$$NPDC_{i,t}(J)=\left[\tilde{\varnothing}_{ji,t}^{N}(J)-\tilde{\varnothing}_{ij,t}^{N}(J)\right]*100$$

Whether $\boldsymbol{NPDC_{i,t}(J)>0}$ it implies that variable $\boldsymbol{i}$ dominates variable $\boldsymbol{j}$; otherwise, if $\boldsymbol{NPDC_{i,t}(J)<0}$ variable $\boldsymbol{i}$ is dominated by variable $\boldsymbol{j}$.

3. Data

In order to study the connectivity of between financial markets in different regions of the world, we have used the MSCI index developed by MSCI Inc. from 21/09/2018 to 28/04/2023 of the developed markets of Europe (EUR), North America (NA), and emerging markets of the Pacific (PAC), Gulf Cooperation Council (GCC), Latin America (EM LA), Asia (ASIA), Europe (EM EUR). **Figure 1** shows each of the MSCI index series.

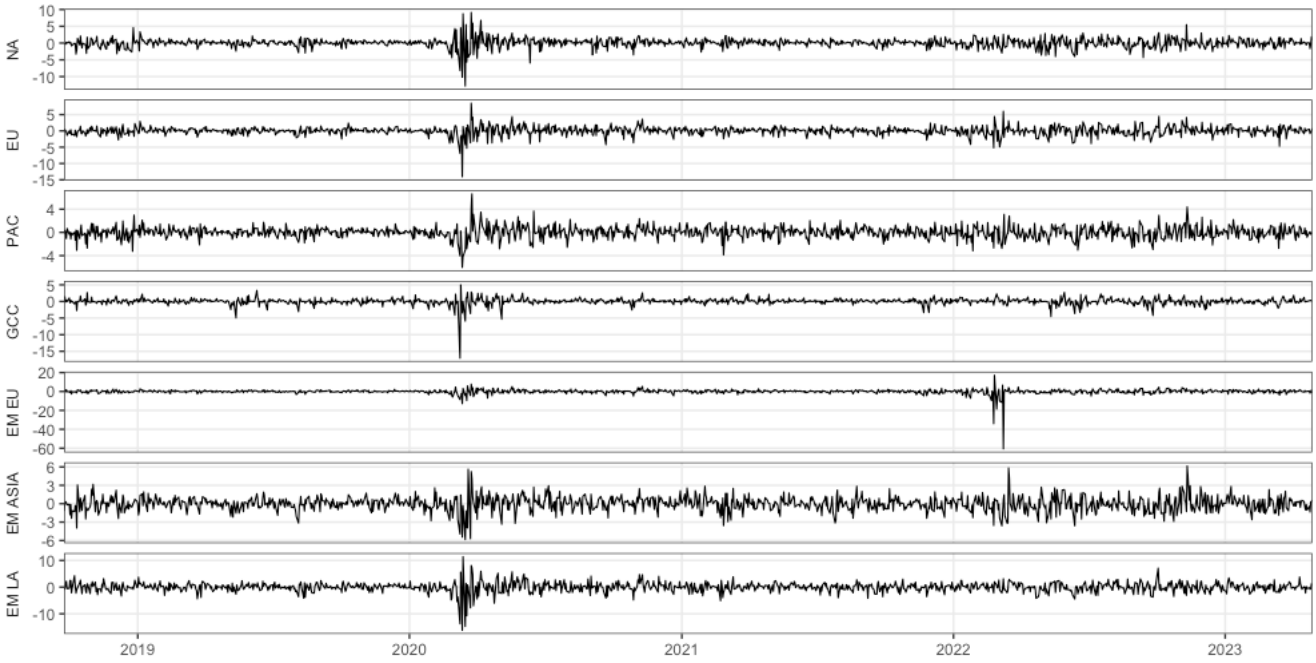
Figure 1. - MSCI Index – Regional Financial Markets



Source: Own elaboration with data obtained from MSCI.com

Considering that the indices exhibit non-stationary behavior, it is necessary to obtain the first logarithmic difference $y_t = ln(x_t) - ln(x_{t-1})$. **Figure 2** shows the returns of each regional market, where at a glance it is possible to identify two important shocks. First, during February 2020 caused by the global COVID-19 pandemic, and second, during February 2022 caused by the armed conflict between Russia and Ukraine.

Figure 2. - Returns MSCI Regional Index



Source: Own elaboration with data obtained from MSCI.COM

Table 1 presents the descriptive statistics of the returns of each regional index, where the kurtosis values and the Jarque-Bera (J-B) test demonstrate the non-normality of the returns, which is a common feature in financial series. In addition, the Phillips-Perron (P-P) test allows us to reject the null hypothesis, which implies stationary returns.

Table 1. - Descriptive Statistics

	Media	*SD*	*Min*	*Max*	*Skewness*	*Curtosis*	*J - B*	*B - P*	*P - P*
NA	0.028	1.397	-12.811	9.127	-0.825	13.164	0.001	0.001	0.01
EUR	0.011	1.299	-14.062	8.524	-1.190	14.806	0.001	0.001	0.01
PAC	-0.002	1.027	-6.031	6.637	-0.061	3.456	0.001	0.001	0.01
GCC	0.019	0.987	-17.057	5.085	-4.963	78.221	0.001	0.001	0.01
EM EUR	-0.093	2.718	-60.688	17.185	-11.191	228.116	0.001	0.001	0.01
ASIA	-0.003	1.196	-5.846	6.157	-0.133	3.180	0.001	0.001	0.01
EM LA	-0.011	1.845	-16.176	11.410	-1.279	13.279	0.001	0.001	0.01

Note: Column J-B and B-P shows the p-values of the Jarque-Bera and Box-Pierce test, respectively with 10 lags. The column P-P, shows the p values of the Phillips-Perron (P-P) test.
Source: Own elaboration with data obtained from MSCI.com

Table 2 shows the unconditional correlations of the returns of each regional index, showing a positive correlation between all markets, which it would explain a homogeneous response to a shock from one

market to the others. The highest correlations are between developed and emerging economies, for instance: NA and EUR with EM LA is 65% and 63.9% respectively. These results suggest a first approach to the possible connectivity between markets.

Table 2. - Correlation between the returns

	NA	*EUR*	*PAC*	*GCC*	*EM EUR*	*ASIA*	*EM LA*
NA	1.000						
EUR	0.608	1.000					
PAC	0.285	0.476	1.000				
GCC	0.279	0.341	0.318	1.000			
EM EUR	0.257	0.429	0.258	0.225	1.000		
ASIA	0.351	0.497	0.614	0.373	0.295	1.000	
EM LA	0.615	0.598	0.351	0.369	0.332	0.422	1.000

Source: Own elaboration with data obtained from MSCI.com

4. Empirical Results

The results of the estimation of connectivity between regional financial markets are shown below. A differentiated analysis is performed for the full period under study and subsamples that identify periods of higher volatility such as covid-19 and the start of the Russia-Ukraine war. Subsequently, a sensitivity analysis estimated through different moving windows is performed.

4.1. Full Sample Analysis

Table 3 presents the directional connectedness full sample, where the inner elements represent the estimated contribution of the variance components to the forecast error variance of the regional market return. In addition, the diagonal elements provide the indirect effects of the returns on their own variables. The results show a total connectedness index of 54.36%, suggesting a high interdependence between regional market returns, which can be interpreted as a high cross-market risk transmission. This index is higher than the findings presented by Ben Amar et al., (2021), which is close to 40%, possibly due to the inclusion of the European emerging markets in the analysis. Our finding implies that on average 54.36% of forecast error variance in these eight markets comes from spillovers and the remaining 45.64% may represent idiosyncratic shocks. However, the directional connectedness to others ( ) has a high variability, ranging from 2.36% (from GCC to PAC) to 19.94% (from NA to PAC).

According to these results, the largest transmitters of return spillover are the developed markets of North America (75.42 - 51.09 = 24.33%) and Europe (81.91 - 61.32 = 20.60%). On the other hand, developed

Pacific countries (39.41 - 66.55 = -27.14%) and GCC countries (18.20 - 37.86 = -19.66) are the largest recipients of return spillover. These results are consistent with those found by Ben Amar et al., (2021).

Table 3. - Directional Connectedness among regional financial markets returns

	NA	*EU*	*PAC*	*GCC*	*EM EU*	*ASIA*	*EM LA*	*FROM*
NA	48.91	17.12	4.75	2.39	8.48	6.81	11.54	51.09
EUR	16.27	38.68	7.03	2.74	16.06	8.35	10.87	61.32
PAC	19.94	15.76	33.45	2.36	9.09	10.45	8.95	66.55
GCC	7.09	6.4	4.41	62.14	7.93	6.16	5.86	37.86
EM EUR	8.59	17.78	5.68	3.77	45.35	7.55	11.29	54.65
ASIA	11.67	12.47	12.03	3.77	9.01	42.5	8.54	57.5
EM LA	11.86	12.39	5.52	3.16	12.01	6.6	48.47	51.53
TO	75.42	81.91	39.41	18.2	62.59	45.91	57.05	380.49
NET	24.33	20.6	-27.14	-19.66	7.95	-11.59	5.52	54.36
NPT	5	6	2	0	4	1	3	

Note: The variance decomposition is based on daily TVP-VAR of lag order 1 with 10-step ahead forecast, chosen according to the Schwartz information criterion.

4.2. Event Analysis

Table 4 shows the estimates considering four sub-samples, considering before and after COVID-19 and the start of the Russia-Ukraine war conflict. Pre-pandemic (24/09/2018 until 31/12/2019), during COVID-19 (01/01/2020 until 31/03/2020), pre Russia-Ukraine War (01/04/2020 until 23/02/2020) and during the armed conflict (24/02/2022 until 31/04/2023).

Prior to the period before the COVID-19 pandemic (**Table 4a**), a relatively high connectivity between regional markets is identified, 55.7%, similar results to those shown in **Table 3**, highlighting the developed North American and European markets as net transmitters of spillover and the developed Pacific and emerging Asian markets as net receivers. In the case of the Latin American market, the results are similar to those found by Ben Amar et al., (2021) where this regional market shows some disconnection with global financial markets on an aggregate basis.

During the COVID-19 period (**Table 4b**) there is greater connectivity between regional markets, reaching a total connectedness index of 76.32%, which is clearly identifiable in **Figure 3**. An important finding is the change in Latin American emerging markets, where in this period of high global uncertainty they became important transmitters of spillover to regional markets, both developed and emerging.

After COVID-19, we consider the period before the Russia-Ukraine war. **Table 4c** shows the estimates, where total connectivity drops to 54.2%, close to the values found before the pandemic. During this period, developed European markets are the main drivers of volatility, which can be attributed to the public health protection measures determined by the European authorities, generating greater uncertainty in the markets.

In the armed conflict (**Table 4d**), total connectivity drops to 48.84%, although the prominence of regional markets is affected. North American markets go from 7.66% net transmission before the armed conflict to 43.89% net spillover transmission, which can be explained by the US support to Ukraine during the war,

triggering uncertainty in international markets. However, developed and emerging markets increased their net receipt of spillover such as the Asian emerging market from -7.26% to 25.33%. An interesting result is presented in the GCC countries, where similar results are presented before and after the armed conflict.

Table 4. - Directional Connectedness among regional financial markets returns at different events

a) Pre-COVID								
	NA	*EUR*	*PAC*	*GCC*	*EM EUR*	*ASIA*	*EM LA*	*FROM*
NA	45.02	19.12	2.74	3.52	10.46	8.49	10.65	54.98
EUR	18.89	40.46	3.63	3.48	14.62	11.44	7.48	59.54
PAC	26.31	15.55	30.26	2.27	8.85	9.71	7.05	69.74
GCC	8.67	7.02	3.08	60.82	7.34	7.66	5.41	39.18
EM EUR	10.05	15.51	3	6.4	43.03	10.58	11.44	56.97
ASIA	13.25	14.55	11	5.66	10.8	37.77	6.98	62.23
EM LA	13.22	9.04	2.61	3.54	12.96	5.92	52.71	47.29
TO	90.38	80.78	26.06	24.87	65.03	53.81	49.01	389.93
NET	35.4	21.23	-43.69	-14.3	8.06	-8.43	1.72	55.7
NPT	4	6	2	0	5	1	3	
b) Covid period								
	NA	*EUR*	*PAC*	*GCC*	*EM EUR*	*ASIA*	*EM LA*	*FROM*
NA	21.75	16.59	8.64	10.45	13.21	9.69	19.68	78.25
EUR	18.84	20.3	7.48	6.62	17.11	10.33	19.32	79.7
PAC	18.59	15.42	15.03	8.28	13.51	10.63	18.55	84.97
GCC	12.6	11.79	7.88	32.73	11.32	7.58	16.1	67.27
EM EUR	17.58	16.96	6.93	5.93	21.9	9.61	21.09	78.1
ASIA	14.84	12.98	12.14	5.63	13.08	26.69	14.65	73.31
EM LA	18.2	13.86	9.58	8.23	14.04	8.72	27.37	72.63
TO	100.64	87.6	52.66	45.14	82.26	56.56	109.38	534.24
NET	22.39	7.9	-32.31	-22.13	4.16	-16.76	36.75	76.32
NPT	5	3	1	1	4	1	6	
c) Pre-Russian and Ukraine war								
	NA	*EU*	*PAC*	*GCC*	*EM EUR*	*ASIA*	*EM LA*	*FROM*
NA	49.26	15.73	5.89	2.03	8.34	7.02	11.74	50.74
EUR	13.42	36.92	8.75	3.5	17.54	7.48	12.37	63.08
PAC	13.09	15.21	38.71	2.49	10.06	11.83	8.6	61.29
GCC	4.94	6.2	4.68	64.6	9.31	5.08	5.17	35.4
EM EUR	7.41	19.41	6.94	4.36	40.96	7.61	13.3	59.04
ASIA	8.91	9.86	13.89	3.71	8.64	46.4	8.58	53.6
EM LA	10.62	14.44	6.58	3.07	14.27	7.31	43.71	56.29
TO	58.4	80.86	46.73	19.16	68.18	46.33	59.77	379.43
NET	7.66	17.78	-14.55	-16.23	9.14	-7.26	3.47	54.2
NPT	3	6	2	0	5	1	4	

d) Russian and Ukraine war period								
	NA	*EUR*	*PAC*	*GCC*	*EM EUR*	*ASIA*	*EM LA*	*FROM*
NA	55.73	18.23	6.69	1.24	3.33	3.12	11.67	44.27
EUR	19.51	42.65	8.72	1.95	11.8	4.76	10.62	57.35
PAC	24.87	18.04	31.37	1.8	5.58	9.05	9.28	68.63
GCC	8.22	4.96	4.77	67.88	4.87	5.53	3.78	32.12
EM EUR	4.1	15.28	5.87	3.79	62.3	2.77	5.9	37.7
ASIA	18.5	12.8	11.02	3.68	3.73	43.35	6.92	56.65
EM LA	12.96	11.72	7.97	2.79	3.63	6.1	54.83	45.17
TO	88.16	81.02	45.03	15.25	32.94	31.32	48.18	341.9
NET	43.89	23.67	-23.6	-16.87	-4.76	-25.33	3	48.84
NPT	6	5	3	0	2	1	4	

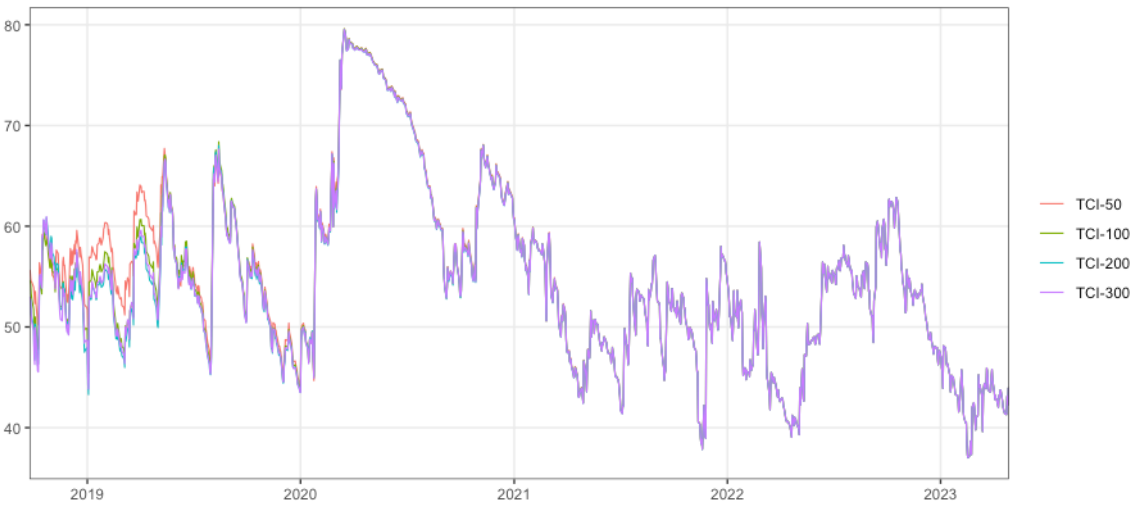
Note: The variance decomposition is based on daily TVP-VAR of lag order 1 with 10-step ahead forecast, chosen according to the Schwartz information criterion

4.3. Sensitivity Analysis

Considering the results above, the connectedness index seems to vary over time. Therefore, **Figure 3** shows the total connectedness index over time, considering different Rolling Windows to check the robustness of the results.

It is possible to identify which prior to the COVID-19 period the use of different Rolling Windows, considering 50, 100, 200 and 300 days in each estimate. Prior to the second quarter of 2019, the use of different Rolling Windows delivered different, although similar, results. On the contrary, since mid-2019, the results are robust independent of the rolling window considered in the analysis.

Figure 3. - Total Connectedness Index (TCI) using different rolling windows



Note: Estimations of the TCI were made using 50,100,200 and 300 days for the Rolling Windows and 10 days ahead for the forecast horizon.

5. Conclusions

This paper investigates the connectivity of regional financial markets (Europe, North America, Pacific countries, Gulf Cooperation Council, Emerging Latin America, Emerging Asia and Emerging Europe) focusing on two recent international events, the COVID-19 pandemic and the Russia-Ukraine war. For this purpose, we use the model developed by (Antonakakis et al., 2020) based on the model of Diebold & Yilmaz (2009, 2012, 2014)

The results show a 54.36% high connectivity between regional financial markets. These results are similar to those found by Ben Amar et al. (2021), which these findings are according with the literature mentioned, where in crisis market connectedness increases.

Then, the sample is divided into four sub-samples, identifying the periods before and after the event (COVID-19 and the Russia-Ukraine war). Prior to the beginning of the pandemic, regional markets presented a connectivity of 55.7%, which increases during COVID-19 to 76.32%, identifying a greater interrelation of markets in this period of high volatility.

Results are different when it comes to analyzing the Russia-Ukraine war, with higher pre-conflict connectivity (54.2%) than during the war (48.84%). This last result seems to be contradictory to what is known in the literature during periods of crisis, but can be attributed to the aggregate data used in the study, as the greatest impact of armed conflict has been documented in the commodity and food markets.

Our findings show that during periods of turbulence, it is necessary to differentiate the extent of the shock. Events such as COVID-19, which wreaked economic, financial and public health havoc worldwide, generate widespread uncertainty in all markets, increasing connectivity and exposing them to greater spillover from global markets. The opposite is the case with armed conflicts where connectivity is relatively unaffected, as it is an event that directly affects some nations and specific markets in which these countries are important.

The results of this study provide important information for policy makers to be cautious about international events and their implications for domestic financial markets. Understanding the dynamic connectedness between international economies allows policy makers to implement actions that ensure the stability of financial systems. For example, by knowing the relationship and impact of an external shock and its determinants, it will be possible for policy makers or regulators to apply corrective or stabilizing actions more effectively.

Other important uses of the results are for investors and portfolio management, re-evaluating investment strategies according to the type of market and international shock. For example, knowing the connectivity between regions will allow investors to pay attention to shocks and their impact on portfolio diversification and hedging strategies, optimizing risk in regions with lower volatility.

A feature of this study is the general analysis at regional level, which is possibly a limitation, but it provides an overview of the behavior of the markets, being possible in future lines of research to extend the results to particular markets and even incorporate proximity or georeferenced variables, particularly because of the results associated with the Russia-Ukraine war.

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