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Asset Connectedness in Times of Crisis: Bitcoin, Commodities, and GCC Stock Markets During the COVID-19 Pandemic and the Russia–Ukraine War

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A R T I C L E I N F O

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A B S T R A C T

This study investigates the dynamic connectedness among stock markets of the Gulf Cooperation Council (GCC) countries, key commodities (WTI crude oil, natural gas, wheat, and gold), and Bitcoin over the period from January 2016 to November 2022. To capture crisis-specific dynamics, the sample is divided into three sub-periods: the pre-crisis baseline (2016–2019), the COVID-19 pandemic (2020–2021), and the Russia–Ukraine war (2022). Using a time-varying parameter connectedness framework, we analyze how health and geopolitical shocks alter spillover patterns, volatility transmission, and the roles of assets as net transmitters or receivers of shocks. Our findings reveal that the Russia–Ukraine war exerted a significantly stronger impact on GCC equity markets than the pandemic, triggering sharper declines in returns and heightened volatility. While financial markets exhibited pronounced interdependence during both crises, international stock indices displayed greater instability compared to commodity markets. Notably, the roles of Bitcoin and gold evolved across crises: during the pandemic, they showed limited integration with GCC markets, but during the war, both assets became active participants in shock transmission—gold transitioning into a net transmitter and Bitcoin reinforcing its dual nature as both a risk amplifier and a conditional diversifier. These results carry important implications for portfolio management and financial policy. Certain commodities, particularly gold, demonstrate context-dependent safe-haven properties, offering effective hedging opportunities during geopolitical turmoil but not necessarily during health crises. For investors, this underscores the need for crisis-aware allocation strategies. From a policy perspective, GCC authorities should integrate dynamic connectedness monitoring into systemic risk frameworks and adapt regulatory responses to the nature of the underlying shock—whether health-related or geopolitical..

1. INTRODUCTION

The current research aims at studying the potential connection stock indices of GCC countries, wheat, oil, gold, gas, and Bitcoin during the periods of the COVID-19 crisis and the Russo-Ukrainian war. Such incidents have got important effect on international financial markets and thus causing turbulence and consequently higher volatility. We thus aim to analyze the relationship among these returns during unstable periods in order to appreciate their mutual effect and connections. The dynamics of such markets are tightly related to universal economic growths, government strategies, health crisis, political instabilities, etc. Appreciating these relations amid these assets offers us an opportunity to recognize interconnections and possible spillovers effects. Through examining connections, tendencies, and

mutual variations, we participate in improving the comprehension of financial trends and risk management.

A detailed analysis of the relationships between stock indices and commodities present interesting perceptions for both portfolio managers and decision makers aiming at finding out efficient decisions in turbulent context. By identifying the links between these markets during turbulent periods, this analysis will contribute to a better understanding of financial interdependencies and the development of more resilient investment strategies. Indeed, the increasing integration in international stock markets has limited diversification gains (Billio et al., 2017), prompting international investors to seek alternative investments such as gold and oil. On the other hand, investment in oil and gold has significantly increased due to financialization.

Furthermore, the weak correlations between commodity and stock markets have caught the attention of market participants who rely on these alternative assets as diversified investments (Hung et al., 2021; Kayral et al., 2023; Béjaoui et al., 2023). Assessing the degree of dynamic dependence between markets is useful in identifying potential diversification benefits and detecting markets vulnerable to international shocks, as well as the market that could be the source of contagion. It is worth noting that in recent years, the prices of gold and oil have become more dependent on stock market shocks (Kang et al., 2021; Dai et al., 2022). Cryptocurrencies, on the other hand, have gained popularity as an investment, offering high returns but also significant risks (Fakhfekh and Jeribi, 2020; Lahiani et al., 2021;). They have also sparked research on portfolio diversification, hedging, and their status as a safe haven for other financial assets (Bouri et al., 2017b; Shahzad et al., 2019; Smales, 2019; Jeribi and Snene Manzli, 2020; Jeribi and Ghorbel, 2021; Loukil et al., 2021).

The COVID-19 pandemic has raised questions about the evolution of the relationship between Bitcoin and other investment assets during this turbulent period. The study purposes to examine the connection between the stock market and Bitcoin during the COVID-19 pandemic and the war in Ukraine. The COVID-19 pandemic has had a major influence in all areas, particularly in the economic, financial, and social realms. Financial markets have been heavily affected, characterized by high volatility of financial assets. Additionally, the war between Russia and Ukraine has also had a significant impact on financial markets and investment assets (Frikha et al., 2023; Béjaoui et al., 2023; Kayral et al., 2023).

The assessment of the dynamic structure of dependency allow the documentation of potential asset that allow portfolios optimization through the analyses of markets sensitivity to international shocks, as well as the market that could be the basis of contagion. Recently, Kang et al., (2019) and Dai et al., (2022) postulate that the prices of commodities as gold and oil have become more dependent on stock market shockwaves. Cryptocurrencies, on the other hand, have become popular as investments, offering high returns but also significant risks (Fakhfekh and Jeribi, 2020; Lahiani et al., 2021). They have also sparked research on portfolio diversification, hedging, and their status as a safe haven for other financial assets (Bouri et al., 2017b; Shahzad et al., 2019; Smales, 2019; Jeribi and Snene Manzli, 2020; Jeribi and Ghorbel, 2021; Loukil et al., 2021).

The COVID-19 pandemic has generated examinations of the dynamic relationship between Bitcoin and other investment assets during unstable periods. This study aims to accurately examine the correlation between the stock market and Bitcoin during the COVID-19 pandemic and the Russo-Ukraine war. Unquestionably, the COVID-19 pandemic has had a significant influence across different domains, specifically in the economic, financial, and social ranges. Financial markets have been heavily affected characterized by high volatility in financial assets. Furthermore, the war between Russia and Ukraine has also left a significant impact on financial markets and investment assets (Frikha et al., 2023; Béjaoui et al., 2023; Kayral et al., 2023). In this line of thoughts, we intend to analyze the interconnectivity between stock market indices of GCC countries, wheat, oil, gold, gas, and Bitcoin during the periods of the COVID-19 crisis and the Russo-Ukraine war.

This study provides valuable insights for investors, portfolio managers, and economic decision-makers who seek to make informed decisions in a complex and ever-changing financial environment. In this third chapter, we will first present a summary of subsequent research. Secondly, we will conduct an empirical study analyzing the connectivity between stock index returns of GCC countries,

commodity prices, and Bitcoin, while evaluating the role of gold and Bitcoin as safe havens or diversification assets during the study period, which encompasses a range of crises.

2. LITERATURE REVIEW

2.1. Connectivity between GCC stock indices and commodities

The correlation between stock prices and international oil prices can be explained through direct and indirect transmission channels: (Mollick and Sakaki, 2019). The direct influence is perceived as oil prices affect future CF, while the indirect effect is observed through their influence on the discount rates (Basher et al., 2012; Ciner, 2013; Mollick and Sakaki, 2019). Previous studies have confirmed the presence of a connection between financial markets and global factors, with disparities based on economic conditions and market particularities (Arouri et al., 2011; Ma et al., 2014; Trabelsi, 2017; Awartani and Maghyereh, 2013; Wen et al., 2019; Cui et al., 2021). However, the outbreak of the COVID-19 pandemic has generated new attentiveness in understanding the connections between financial markets and oil prices.

Recent research has exposed a sharp impact of the oil shock on GCC stock returns during the pandemic compared to stable periods (Abuzayed and Al-Fayoumi, 2021). Though, studies examining the connection between oil prices and stock prices during the COVID-19 pandemic have generated diverse results (Salisu et al., 2020; Prabheesh et al., 2020b; Mzoughi et al., 2020; Prabheesh et al., 2020a; Wang et al., 2021). During COVID-19, the forces of supply and demand especially in agriculture increased worries about food safety (Clapp and Moseley, 2020; Schmidhuber, 2020; Musa et al., 2020; Ramakumar, 2020; Poudel et al., 2020; Salisu et al., 2020; Elleby et al., 2020). Examining the spillover effect and volatility transmission, researchers found that for GCC stock indices investors, the crude oil is an efficient hedge asset, (Jouini and Harrathi, 2014; Gutierrez and Pierre, 2022). Globally, researches on connections dynamics between stock markets indices offer a good framework to a better understanding of the prominence of commodities such as oil prices, gold, and global factors as geopolitical events in designing financial changements.

2.2. Connectivity among GCC stock indices, Bitcoin, and gold".

A significant empirical and theorical literature has been developed on the connection between gold and stock indices. Numerous studies have examined the link between gold and stocks, as well as the possible role of gold as an effective asset to hedge portfolios during stable and unstable periods (Maghyereh et al., 2017). The COVID-19 pandemic has been a decisive test for cryptocurrencies as a safe haven, leading to a proliferation of studies examining the potential role of cryptocurrencies (Jeribi and Snene Manzli, 2020; Jeribi and Ghorbel, 2021; Loukil et al., 2021). Studies have shown that both oil and gold are hedging instruments, but at a substantial cost (Maghyereh et al., 2017). There are significant transmissions of oil shocks to GCC country indices, underlining the strong dependency of local economies on oil (Maghyereh et al., 2017). The transmission of gold shocks to stock markets is irrelevant, meaning that fluctuations in the price of gold do not certainly effect investment decisions in stocks (Maghyereh et al., 2017). Charfeddine and Al Refai (2019) examined the impact of political and economic emergencies on stock market interdependence and chock transfer between Qatar and other GCC states. The results show that only the new GCC crisis has meaningfully affected the interdependence between stock markets (Charfeddine and Al Refai, 2019).

Al Maadid et al. (2019) studied the effect of economic and political news on financial market returns in Gulf countries. The results highlight the importance of news as drivers of stock returns in GCC countries (Al Maadid et al., 2019). Yahyaee et al. (2019) investigated the risk spread between precious metals, energy, and GCC stock markets. The results prove significant risk spillover between energy and stock markets (Yahyaee et al., 2019).

2.3. Connectivity between Bitcoin, gold, oil, wheat and gas

In examining the empirical studies conducted by various authors, we delve into the relationships and roles of these assets in the context of stock markets, periods of economic turmoil, and global crises for instance the COVID-19 pandemic. The work of Basher and Sadorsky (2016) highlights that the price of oil can provide effective hedging for stock prices in emerging markets. Furthermore, Bdowska-Sójka and Kliber (2021) emphasize that gold positions itself as the only appropriate safe

haven asset for all markets, particularly prior to the advent of the COVID-19 pandemic. The study by Chemkha et al. (2021) reveals that during the pandemic period, gold can only serve as a weak safe haven, while the increased volatility of Bitcoin limits its ability to act as a refuge for any market. Madani et al. (2021), on the other hand, shed light on the hedging and safe haven performance of Bitcoin over a short investment horizon. They find that Bitcoin can serve as a weak hedge during moderate fluctuations, but its utility against stocks, crude oil, and currencies is limited.

The work conducted by Wen et al. (2022) unequivocally confirms gold's superiority as a safe haven asset when compared to Bitcoin. Their study highlights that, mainly in the midst of the COVID-19 pandemic, only gold can actually be a reliable refuge for both energy and stock markets. Additionally, Ghorbel and Jeribi (2021) shed light on the features of cryptocurrencies, such as Bitcoin, enlightening their low correlation and high volatility transmission among themselves, but a weak volatility transmission with US stock indices. By analyzing these empirical studies, we gain invaluable insights into the behavior of these assets across various market contexts.

In summary, the results of various studies underscore the significant role that gold plays as a safe haven, while Bitcoin exhibits increased volatility and is not always regarded as a reliable refuge. Traditional assets such as oil and stock indices also demonstrate significant correlations with other assets, although the nature of these relationships may vary depending on the economic periods and contexts. Such empirical review offers an interesting comprehension of the relationship between these assets and affords valued intuitions for portfolios managers and decisions makers.

3. METHODOLOGY

Our study focuses on examining the dynamic interconnections amid the stock returns of GCC, the prices of oil, gas, wheat, gold, and Bitcoin. Our sample covers the period from January 1, 2016, to November 30, 2022, and is separated into three sub-periods to consider the COVID-19 pandemic and the war between Russia and Ukraine.

The chosen econometric methodology is the multivariate time series approach of Diebold and Yilmaz (2009, 2012, 2014). Their approach allows to study the connections between the stock of GCC index returns and the prices of various commodities as oil, gas, wheat, gold, and Bitcoin. We use the VAR (vector autoregressive model) framework and GFVD (generalized forecast variance decomposition) to study the connectivity and permit the measure of overall influence amid the studied variables.

Thus, we apply this methodology and calculate returns using the formula rt = ln(Pt/Pt-1), where Pt represents the price at a given time which allow us to inspect the connectivity in the return system between the financial assets and commodities during the stable period COVID-19 crisis, and the war between Russia and Ukraine. The advantage of the Diebold and Yilmaz (2009) approach is to appreciate the connection between financial markets.

First, let us consider a VAR model with K variables and a lag order of p:

$$y_t = \sum_{i=1}^{\rho} \Phi_i \, y_{t-1} + \varepsilon_t \qquad (1)$$

Let consider that yt is a vector (K×1) of different variables at time t, Φi is a matrix of autoregressive coefficients, and εt is a vector (K×1) of expected uncorrelated error terms. Assumed a covariance stationary VAR system, a moving average illustration is written as follows:

$$y_t = \sum_{i=1}^{\infty} A_j \varepsilon_{t=j} \qquad (2)$$

The method suggested by Koop et al. (1996) and Pesaran et Shin (1998) includes decomposing the variance of the global forecast error by step H, where the coefficient matrices have dimensions of n×n, with A0 being the n×n identity matrix and Aj = 0 for j < 0. The variance contribution of variable j to variable i can be designed using the following decomposition.

$$\theta_{ij}(H) = \frac{\sigma_{h=0}^{-1} \sum_{h=0}^{H-1} \left(e_i' \, A_h \sum e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' \, A_h \sum A_h' e_i\right)} \qquad (3)$$

Finally, the net connectivity between pairs, directional connectivity, and total connectivity can be calculated using the decomposition of the variance of the generalized forecast errors (FEVD).

3.1. Net connectivity between pairs:

As a result of the existence of an asymmetric effect between two variables and the fact that CHi←j ≠ CHj←i, we measure the net connectivity between pairs as the difference amid CHi←j and CHj←i. Such a difference, CHi←j - CHj←i, processes the net

contagion influence from variable j to variable i. Using the net connectivity between these pairs, a directional connectivity system can be constructed.

3.2. "From", "To" and "TCI":

According to table 1, the "From" column and the "To" row measure the total directional connectivity "TCI" from and to each market. The total directional connectivity "From" is defined as the diffusion of information from other markets to a given market, and this value ranges from 0 to 1.

3.3. Total Net Directional Connectivity

The difference among the total directional connectivity "To" and "From" a market captures the net contribution of information diffusion.

3.4. Total Connectivity for the System

The mean value of the whole directional connectivity "From" or "To" across entirely variables provides a comprehensive measure of the system's overall connectivity. This indicator effectively represents the level of integration and convergence within the market.

Merely analyzing connectivity based on the complete sample fails to shed light on the dynamic nature of connectivity. Consequently, DY (2009) expand this measure by incorporating over time varying spilover effects. The TVP-VAR model is employed to estimate the relationships between the different components of the system over time, and the sliding window approach is utilized to account for changes in these relationships.

4. DATA ANALYSIS

Estimating dynamic connectivity measures for three different systems are presented as follow. The first system focuses on the relationship between stock market indices of GCC countries, as well as the prices of oil, wheat, and gas. The second system expands upon the first by including not only the GCC indices but also the returns of gold and Bitcoin. Lastly, the third system encompasses the returns of oil, wheat, gas, gold, and Bitcoin. This study is divided into three sub-periods: pre-COVID, during COVID, and during the war. These results are resultant from the TVP-VAR model, which help analyzing connection amid these markets.

4.1. Connectivity between stock indices, oil, wheat and gas

The descriptive analysis in Table 1 reveals that the stock market returns of Gulf countries have been more negatively affected by the crisis related to Russian military actions in Ukraine than by the pandemic. In fact, they have shown lower or even negative returns, as well as higher volatility. Furthermore, the results of skewness statistics show that all the studied assets exhibit asymmetric distributions, either to the left or to the right, and this asymmetry depends on the period, indicating that it is related to the events and assets under study. The analysis of kurtosis shows that the kurtosis values are high for all commodities, with some variations depending on the chosen study period. However, in general, they all exhibit an asymmetric distribution according to the Jarque Bera statistic.

Table 1: Descriptive Statistics variables

Variable	BAX	FTGPCST	MSM30
Before COVID-19			
Moyenne	.0002362	.0002362	.0002362
Variance	.0110999	.0110999	.0110999
Skewness	0.178**	-0.486***	-0.055
Ex.Kurtosis	360.049***	5.648***	5.701***
JB	5801176.922***	1470.100***	1455.077***
During COVID-19			
Mean	.0004486	.0005399	.0000244
Variance	.0059688	.0120312	.0055566
Skewness	0.406**	-0.196	0.913***
Ex.Kurtosis	5.463***	2.475***	3.133***
JB	254.166***	52.325***	109.592***
During war			
Mean	-.0001674	.0002734	.0006464
Variance	.0066777	.008047	.0061156

Skewness	0.406**	-0.196	0.913***
Ex.Kurtosis	5.463***	2.475***	3.133***
JB	254.166***	52.325***	109.592***

Variable	QEAS	TASI	ADI
Before COVID-19			
Moyenne	.0002362	.0002362	.0002362
Variance	.0110999	.0110999	.0110999
Skewness	-0.584***	-0.935***	-0.225***
Ex.Kurtosis	9.235***	8.415***	5.242***
JB	3877.239***	3325.310***	1238.799***
During COVID-19			
Mean	.0007422	.0011847	.0013138
Variance	.0087223	.0105259	.0126336
Skewness	-0.152	-0.542***	-0.672***
Ex.Kurtosis	8.479***	1.559***	6.119***
JB	599.870***	30.069***	327.026***
During war			
Mean	-.0002153	-.0007062	.0007388
Variance	.0125775	.0109953	.0102644
Skewness	-0.152	-0.542***	-0.672***
Ex.Kurtosis	8.479***	1.559***	6.119***
JB	599.870***	30.069***	327.026***

Variable	WTI	WHEAT	GAS
Before COVID-19			
Moyenne	.0002362	.0002362	.0002362
Variance	.0110999	.0110999	.0110999
Skewness	0.257***	0.286***	-0.083
Ex.Kurtosis	4.187***	0.996***	5.013***
JB	796.527***	59.027***	1125.757***
During COVID-19			
Mean	.0015735	.000905	.0019524
Variance	.0511659	.0175228	.0413976
Skewness	-0.423**	0.763***	-0.496***
Ex.Kurtosis	0.858**	5.424***	0.877**
JB	12.096***	264.565***	14.603***
During war			
Mean	-.0006597	-.0002974	.0021611
Variance	.0324789	.034602	.0508564
Skewness	-0.423**	0.763***	-0.496***
Ex.Kurtosis	0.858**	5.424***	0.877**
JB	12.096***	264.565***	14.603***

Source: Authors

Regarding the total connectivity in this VAR system, it is 19.31, 26.92, and 32.92 respectively before COVID-19, during COVID-19, and during the war. This result highlights the presence of a moderate dependence effect during the stable period before COVID, and a contagion effect during the crises (COVID-19 and war).

During the three different periods (before COVID, during COVID, and during the war), the average influence of stock market indices varies significantly. Before COVID, the average influence is approximately 129%, during COVID it increases

to 182%, and during the war, it reaches the peak of 211.5%. Furthermore, on average effect of commodities is comparatively lower. Before COVID, the average influence is about 25.51%, during COVID it reaches 33.34%, and during the war, it reaches to 52.2%. These high values suggest that the spillover effects from the international stock market play a considerable role in explaining market dynamics during unstable periods compared to the commodities market.

Analyzing the status of net transmitter and net receiver, the results show that during stable periods, BAX, FTGPCST, MSM30, and QEAS are net receivers, while TASI, ADI, Oil, Gas, and Wheat are net transmitters. However, this observation does not hold during times of crisis (COVID and war). In fact, during COVID-19, in addition to BAX and MSM30, the returns of ADI, Oil, and Gas become pure recipients of shocks, while FTGPCST, QEAS, TASI, and Wheat are pure financial assets that transmit shocks. What is striking is that during the war, BAX, FTGPCST, MSM30, QEAS, Wheat, and Gas become pure recipients of shocks, unlike the returns of TASI, ADI, and Oil, which become pure transmitters of risks. This result is consistent with the study by Salem Adel Ziadat et al. (2021), which concluded that during the COVID-19 period, Kuwait was the largest net beneficiary of volatility transmitted by other GCC countries, followed by Oman, Qatar, and Abu Dhabi, while Saudi Arabia, Bahrain, and Dubai were net transmitters of volatility shocks to other countries. We can conclude that wheat, gas, and oil are diversification assets during stable periods (pre-COVID). Oil and gas serve as safe havens during the pandemic, while wheat and gas, not oil, act as safe havens during times of war.

Table 2: Total static connectivity for GCC stock indices and commodities returns

	BAX	FTGPCST	MSM30	QEAS	TASI	ADI	WTI	WHEAT	GAS	FROM
Before COVID										
BAX	94.86	1.23	0.38	0.33	0.88	0.50	0.42	1.36	0.04	5.14
FTGPCST	1.26	77.89	3.35	4.95	6.42	4.80	0.80	0.25	0.28	22.11
MSM30	0.53	2.54	81.18	3.52	4.06	4.75	2.62	0.16	0.64	18.82
QEAS	0.55	4.09	3.40	69.33	6.59	11.89	3.36	0.32	0.46	30.67
TASI	1.03	3.18	3.36	5.22	73.05	7.71	5.67	0.22	0.58	26.95
ADI	0.47	4.02	4.30	11.10	7.83	68.85	2.82	0.44	0.16	31.15
WTI	0.51	0.52	0.77	2.55	3.84	2.83	86.79	0.91	1.28	13.21
Wheat	0.42	0.54	0.16	0.28	0.39	0.32	1.15	96.72	0.03	3.28
Gaz	0.03	0.28	0.65	0.04	0.56	0.07	1.48	0.06	96.82	3.18
TO	4.81	16.40	16.39	27.98	30.56	32.86	18.32	3.71	3.48	154.51
Inc.Own	99.67	94.29	97.57	97.31	103.61	101.71	105.11	100.43	100.30	cTCI/TCI
NET	-0.33	-5.71	-2.43	-2.69	3.61	1.71	5.11	0.43	0.30	19.31/17.17
NPT	5.00	2.00	2.00	2.00	5.00	5.00	6.00	5.00	4.00	
Before COVID										
BAX	69.69	12.28	0.47	4.47	6.01	2.61	1.62	2.50	0.37	30.31
FTGPCST	8.83	64.63	0.66	5.13	10.77	6.86	2.31	0.42	0.39	35.37
MSM30	0.56	0.97	87.27	2.92	2.56	1.62	0.74	2.31	1.04	12.73
QEAS	2.88	4.01	1.84	67.93	12.52	7.05	2.47	0.43	0.87	32.07
TASI	3.26	8.27	1.16	10.54	63.95	8.96	2.74	0.60	0.53	36.05
ADI	1.85	7.39	1.77	7.51	10.19	66.46	3.16	0.76	0.90	33.54
WTI	1.23	2.74	0.84	2.18	4.36	4.96	80.78	1.86	1.03	19.22
Wheat	0.68	0.61	0.83	2.47	0.49	0.19	2.25	91.17	1.30	8.83
Gaz	0.18	0.82	0.19	0.84	1.18	1.27	1.74	0.99	92.78	7.22
TO	19.48	37.10	7.76	36.06	48.07	33.53	17.04	9.87	6.43	215.33
Inc.Own	89.16	101.73	95.03	103.99	112.02	99.99	97.82	101.04	99.21	cTCI/TCI
NET	-10.84	1.73	-4.97	3.99	12.02	-0.01	-2.18	1.04	-0.79	26.92/23.93
NPT	1.00	6.00	2.00	5.00	7.00	3.00	4.00	4.00	4.00	
Before COVID										

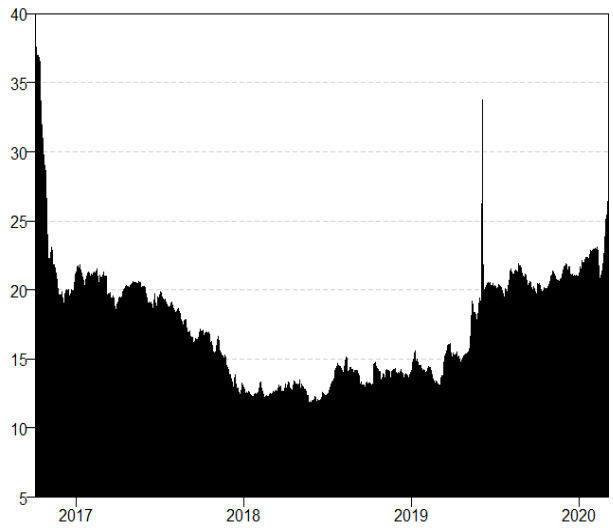
	BAX	FTGPCST	MSM30	QEAS	TASI	ADI	WTI	WHEAT	GAS	FROM
BAX	66.70	7.16	1.60	5.21	9.90	5.24	2.70	0.99	0.51	33.30
TGPCST	5.35	54.42	0.59	5.14	14.41	16.25	2.31	1.09	0.45	45.58
MSM30	2.09	0.19	91.03	2.79	2.22	0.15	0.36	0.78	0.38	8.97
QEAS	5.30	4.06	1.93	63.43	12.67	9.24	3.10	0.18	0.09	36.57
TASI	7.69	10.95	0.39	9.78	55.42	12.29	2.51	0.37	0.59	44.58
ADI	3.87	15.03	0.19	7.90	13.31	56.80	1.30	1.03	0.58	43.20
WTI	1.84	0.27	0.47	1.22	3.78	1.23	79.92	7.82	3.43	20.08
Wheat	0.38	0.81	0.71	0.14	1.01	0.88	12.45	79.30	4.33	20.70
GAZ	0.15	0.55	0.09	0.05	2.85	1.84	3.16	1.72	89.60	10.40
TO	26.67	39.01	5.97	32.23	60.16	47.11	27.87	13.97	10.36	263.36
Inc.Own	93.37	93.43	97.01	95.67	115.58	103.92	107.80	93.27	99.97	cTCI/TCI
NET	-6.63	-6.57	-2.99	-4.33	15.58	3.92	7.80	-6.73	-0.03	32.92/29.26
NPT	2.00	2.00	3.00	2.00	8.00	4.00	5.00	5.00	5.00	

Source: Authors

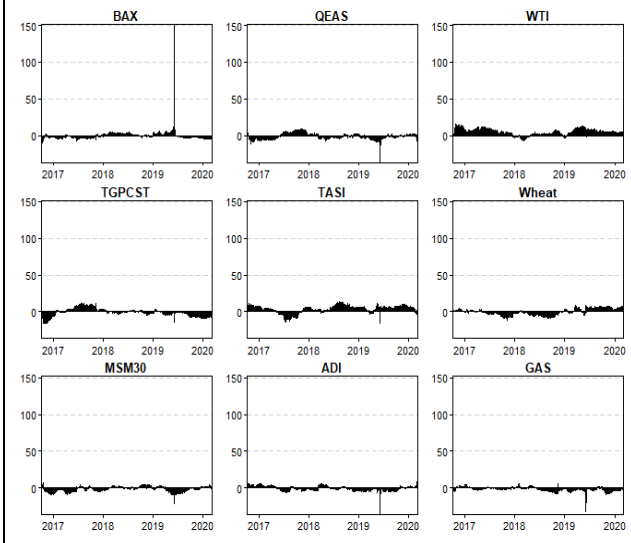
Moving on to the dynamic analysis of total and net connectivity curves, it is evident that total connectivity before COVID experienced variations averaging around 25%, with a minimum of 12% and a temporary maximum of 35%. This is not the case during crises, where connectivity reaches higher and more persistent values over time. Indeed, during COVID, it peaked at over 30%, followed by a period of normalization, and then a sustained period of connectivity exceeding 40%. During the war, total connectivity notably surpassed 35%, reaching a maximum of 40% before returning to 30% in early November 2022.

Before COVID

Total dynamic connectedness



Net dynamic connectedness



During COVID

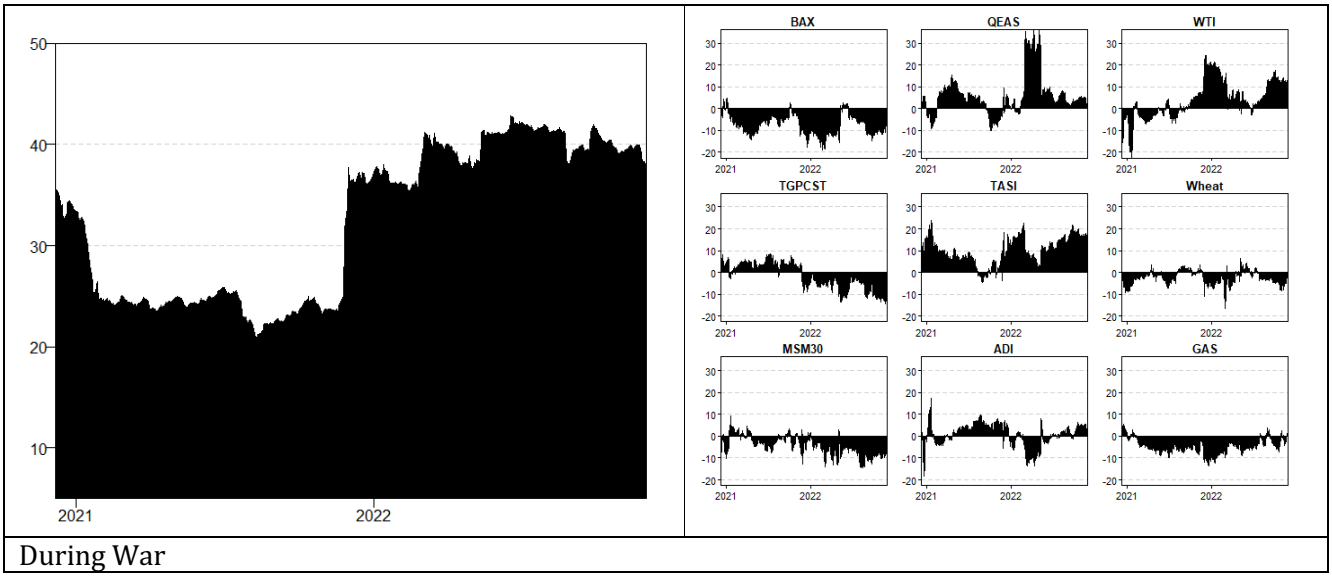


Figure 1: Dynamic total and net connectedness for GCC stock indices and commodities returns

Next, we observed that the indices of GCC countries have different statuses and therefore respond differently to shocks. During the health crisis, BAX 30, MSM 30, wheat, and gas are pure recipients, while TASI is a pure transmitter. Additionally, QEAS, FTGPCT, ADI, and oil have heterogeneous statuses as both transmitters and recipients. This result is in part explained by Albulescu's study (2020), which concludes that the GCC economy is exposed to a dual shock: the spread of the COVID-19 pandemic and the decline in oil prices, which can lead to long-term economic slowdown. As oil markets are generally closely linked, the volatility in the oil market has influenced investor behavior and shaken stock markets. During the Russian military actions against Ukraine, we noticed that wheat and Oman's stock index are pure recipients of shocks, while TASI is a pure transmitter of shocks to the system. Furthermore, BAX, ADI, and FTGPCT initially act as pure transmitters until early October when they become pure recipients of system shocks. Finally, QEAS and gas are pure recipients of shocks but change their statuses in early October to become pure transmitters of shocks. It is important to note the significant implications of these findings for understanding the dynamics of the GCC economies and their vulnerability to external shocks. The differential responses of various indices highlight the complex interplay between different factors and the need for careful analysis and monitoring of market behavior. By gaining a deeper understanding of these dynamics, policymakers and investors can make more informed decisions to mitigate risks

and promote stability in the region.

4.2. Connectivity between stock indices, Bitcoin and gold

The results extracted from Table 3 demonstrate a sharp decline in the average returns of BTC and gold, particularly during the war, reaching negative average returns accompanied by relatively significant values of the standard deviation. This finding could be attributed to the existence of explanatory factors other than volatility. On the other hand, the results indicate that all assets are in general, all asymmetrically distributed according to the Jarque Bera statistic.

Table 3: descriptive statistics

	Gold	BTC	Gold	BTC	Gold	BTC
Before COVID			During COVID		During war	
Mean	.0004248	.0028352	.0002555	.0027621	-.0003398	-.00402
Variance	.0076642	.0456929	.0102621	.0498514	.0096604	.0437963
Skewness	0.183**	-0.076	-0.743***	-1.938***	0.096	-1.756***
Ex.Kurtosis	2.447***	4.122***	4.069***	19.844***	0.724*	9.464***
JB	274.015***	761.320***	405.814***	8840.792***	4.678*	849.183***

Source: Authors

The results of the Total Connectivity Index (see table 4) show a remarkable increase in connectivity during times of crisis compared to periods of stability. TCI index goes from 16.03 before COVID to 24.98 during COVID and 31.20 during the war. Prior to COVID-19, the results indicate that FTGPCST, MSM30, QEAS, and Bitcoin emit less volatility than they receive from the system. During COVID-19, all stock indices emit less volatility than they receive from the system, except for Saudi Arabia. These findings contradict the results of the study conducted by Mehmet Balcilar et al. (2022). Furthermore, it is evident that the Saudi Arabian stock market is identified as the main risk vector during the post-COVID period (46.86). On the other hand, gold and Bitcoin emit more volatility than they receive from the system. On average, they act as pure transmitters of volatility.

Table 4: Total static connectivity for GCC stock indices, Gold and Bitcoin returns

	BAX	FTGPCST	MSM30	QEAS	TASI	ADI	Or	BTC	FROM
Before COVID									
BAX	96.40	1.26	0.36	0.32	0.82	0.48	0.08	0.27	3.60
TGPCST	1.26	79.22	3.40	4.9	6.29	4.77	0.09	0.03	20.78
MSM30	0.49	2.62	82.74	3.8	4.65	5.13	0.19	0.33	17.26
QEAS	0.57	4.18	3.74	70.99	7.39	12.61	0.38	0.14	29.01
TASI	1.01	3.30	3.90	6.06	76.27	8.43	0.88	0.14	23.73
ADI	0.45	4.04	4.66	11.76	8.36	70.31	0.11	0.32	**29.69**
Or	0.14	0.12	0.31	0.10	0.73	0.22	98.09	0.30	1.91
BTC	0.13	0.17	0.35	0.46	0.30	0.53	0.33	97.73	2.27
TO	4.05	15.68	16.72	27.49	28.53	**32.18**	2.07	1.52	128.24
Inc.Own	100.45	94.90	99.46	98.48	104.80	102.49	100.16	99.26	cTCI/TCI
NET	0.45	-5.10	-0.54	-1.52	4.80	2.49	0.16	-0.74	18.32/16.03
During COVID									
BAX	70.31	14.35	0.55	4.31	6.39	2.78	0.77	0.53	29.69
FTGPCST	10.46	66.56	0.56	3.25	9.65	5.23	2.01	2.26	33.44
MSM30	1.15	0.65	85.46	2.71	3.19	2.83	2.44	1.56	14.54
QEAS	3.19	2.79	1.39	69.99	12.09	7.34	1.22	1.99	30.01
TASI	3.91	7.19	1.10	9.28	64.39	9.05	1.18	3.89	35.61
ADI	2.52	5.41	1.04	6.70	11.14	65.43	2.68	5.10	34.57
Or	0.88	1.55	1.92	0.42	1.22	0.96	90.34	2.72	9.66
BTC	0.51	1.48	1.15	0.78	3.17	2.35	2.85	87.70	12.30
TO	22.62	33.41	7.71	27.45	**46.86**	30.55	13.16	18.05	199.81
Inc.Own	92.93	99.97	93.17	97.44	111.25	95.98	103.50	105.75	cTCI/TCI
NET	-7.07	-0.03	-6.83	-2.56	11.25	-4.02	3.50	5.75	28.54/24.98
During War									
BAX	66.80	7.47	1.30	4.88	9.32	4.87	3.70	1.66	33.20
FTGPCST	5.48	55.25	0.58	5.01	14.02	15.90	0.94	2.82	44.75

MSM30	1.73	0.33	90.27	2.29	1.94	0.04	2.48	0.90	9.73
QEAS	4.94	3.91	1.60	63.87	11.89	8.23	3.03	2.54	36.13
TASI	7.11	10.26	0.23	8.91	54.79	10.90	1.93	5.87	45.21
ADI	3.64	14.55	0.10	6.90	11.98	56.06	1.82	4.94	43.94
Or	4.29	2.32	2.41	3.13	5.36	2.69	77.00	2.81	23.00
BTC	1.25	0.60	0.06	0.31	5.10	2.15	4.16	86.37	13.63
TO	28.44	39.45	6.29	31.44	59.61	44.77	18.06	21.54	249.60
Inc.Own	95.23	94.69	96.56	95.31	114.40	100.83	95.06	107.91	cTCI/TCI
NET	-4.77	-5.31	-3.44	-4.69	14.40	0.83	-4.94	7.91	35.66/31.20

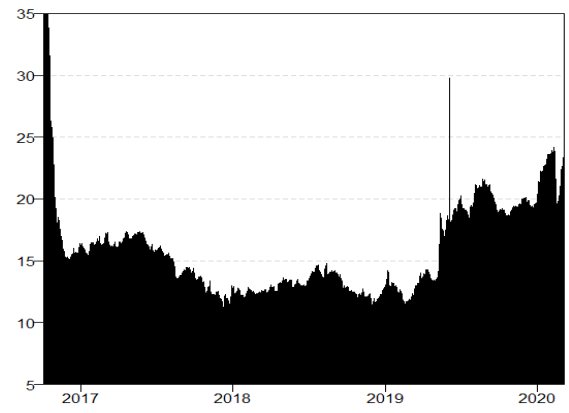
Source: Authors

During the Russian military actions, it is apparent that the stock indices of Gulf countries and gold are on average recipients of shocks except TASI and ADI, meaning they emit less volatility than they receive. On the other hand, Saudi Arabian and UAE stock indices, and Bitcoin are on average pure transmitters of shocks in the studied system. This finding is consistent with the study conducted by Salem Adel Ziadat et al. (2021). The authors' findings suggest that during the financial crisis from 2008 to 2010, Kuwait and Bahrain were the main receivers of chock transmissions among the GCC region while, the Saudi Arabia and Abu Dhabi markets were the least net receivers, meaning they were the main net emitters of volatility. Such result is somehow explained by the enormous oil production and thus the substantial revenues permitting these countries to relieve markets concerns. Similarly, this financial net funded by oil can spread fear through the region. The results also showed that during the war, Kuwait was the largest receiver of chock (-5.31), followed by Bahrain, Qatar and Oman. Finally, while Bitcoin is a net transmitter Gold is a net receiver of volatility.

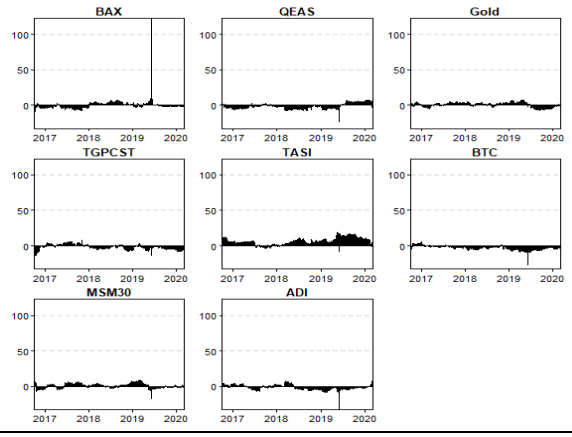
Based on these results, we can conclude regarding the diversification or hedging strategy of portfolios during the stability period (pre-COVID) and during the two crises, namely the health crisis and the military crisis. Indeed, the results show that gold is a means of diversification, while Bitcoin is a means of hedging before COVID-19. During the global pandemic, the roles of gold and Bitcoin have undergone significant changes, emerging as means of portfolio diversification for investors. Moreover, when it comes to the context of war, the findings demonstrate that gold serves as a safe haven, while Bitcoin continues to play its role in diversifying investors' portfolios amidst this crisis.

Before COVID

Total dynamic connectedness



Net dynamic connectedness



During COVID

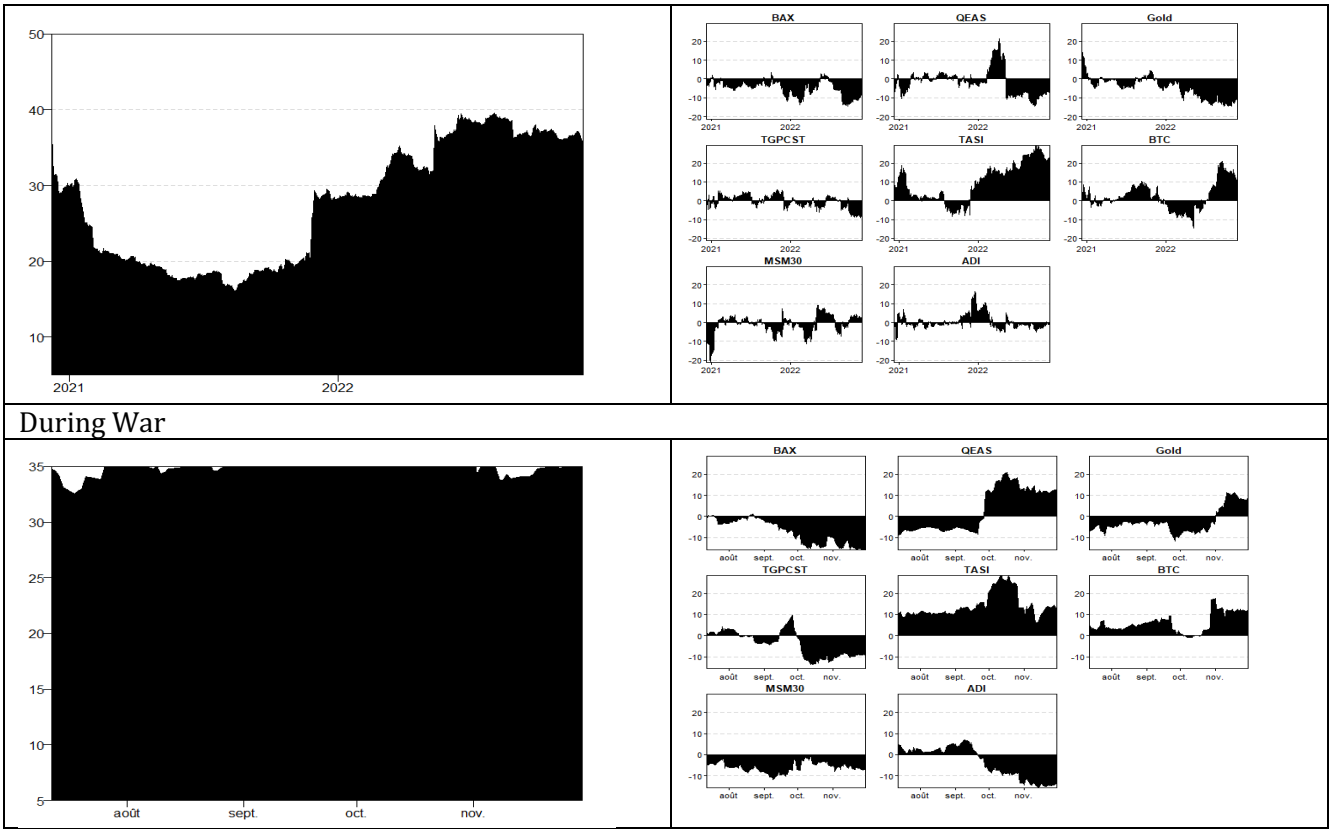


Figure 2: Dynamic total and net connectedness for GCC stock indices, Gold and Bitcoin

Regarding the dynamic analysis of the status of the assets (Figure 2) studied as shock transmitters or receivers, the results indicate that during the pre-COVID period, the studied indices, Bitcoin and gold, were either weak transmitters or weak receivers. It is noteworthy that this observation does not hold true during the period of the health crisis. Indeed, BAX is a pure receiver, while for FTGPCST, there is a compensation between shock reception and emission to the system. Additionally, TASI is a strong risk emitter, while MASM30, ADI, and QEAS have heterogeneous statuses over time. Furthermore, gold, Bitcoin, and other indices have heterogeneous statuses as both transmitters and receivers of shocks. This result is in part consistent with the study by Thanh Ha et al. (2022), which concluded that the cryptocurrency market acts as both a net receiver and net emitter, varying over time. Additionally, they demonstrated that the gold and stock markets consistently act as net receivers of contagion shocks.

During times of war, we observe that the magnitude of shock transmission and reception is more significant and persistent over time. Specifically, it is evident that BAX and MSM30 are pure shock receivers, unlike Bitcoin and TASI, which are pure shock transmitters to the system. We also note that gold and QEAS act as receivers and transform into shock emitters in November and October, respectively. Finally, FTGPCST has a more heterogeneous status.

Table 5: Statistic variables

	BTC	Or	Wheat	Gaz	WTI
Before COVID					
Mean	.0028352	0.0004248	0.0001222	-0.0003089	0.0001274
Variance	.0456929	0.0076642	.0168622	0.0281014	0.0220387
Skewness	-0.076	0.183**	0.286***	-0.083	0.257***
Ex.Kurtosis	4.122***	2.447***	0.996***	5.013***	4.187***
JB	761.320***	274.015***	59.027***	1125.757***	796.527***

WTI	0.000	0.011	0.059***	0.088***	1.000***
During COVID					
Mean	.00089	.0000809	.000515	.0019754	.0009429
Variance	.0483122	.0100985	.0235732	.0442507	.0466864
Skewness	-2.028***	-0.757***	0.362***	0.229**	-3.069***
Ex.Kurtosis	20.911***	4.145***	0.133	2.356***	45.900***
JB	9622.306***	412.979***	11.473***	122.170***	45481.799***
During war					
Mean	-.00402	-.0003398	-.0002974	.0021611	-.0006597
Variance	.0437963	.0096604	.034602	.0508564	.0324789
Skewness	-1.756***	0.096	0.763***	-0.496***	-0.423**
Ex.Kurtosis	9.464***	0.724*	5.424***	0.877**	0.858**
JB	849.183***	4.678*	264.565***	14.603***	12.096***

Source: Authors

4.3. Study on the Connectivity between Commodity Returns and Bitcoin:

Our analysis (see table 5) reveals a significant decline in Bitcoin, WTI, Gold and Wheat returns during the pandemic and reaching its lowest point, and negative returns during the war. This decline is accompanied by an increase in the standard deviation, indicating heightened volatility during the COVID-19 crisis. However, this trend does not hold true for the Gas return, suggesting a unique dynamic at play. Unlike the other commodities, natural gas experienced a shift from negative to positive returns during both the pandemic and the war. This finding aligns with the research conducted by Saqib Farid et al. (2021), highlighting the lower volatility of natural gas compared to other assets during the COVID-19 epidemic. Furthermore, our analysis examines the presence of asymmetric distribution, revealing that all commodities exhibit this characteristic.

Prior to the global COVID-19 pandemic, an analysis of connectivity (Table 6) revealed that wheat and Bitcoin were more prone to receiving risk from the system than emitting it. Consequently, they were considered net risk receivers, while oil, gas, and gold emitted more risk to the system than they received, making them net risk transmitters. It is worth noting that oil is the most significant transmitter and receiver of risk (2.73). The analysis of total dynamic connectivity shows that the period before COVID is characterized by low total connectivity, with a maximum of 6% before 2019 and not exceeding 9% thereafter. By analyzing net dynamic connectivity, we notice that Bitcoin, gold, and oil have heterogeneous statuses, while gas and wheat are emitters until the end of 2017 and become net receivers until the end of the period just before the WHO declaration of the global epidemic.

These findings do not hold during the pandemic. In fact, all commodities receive more shocks from the system than they emit, except for oil, which is a pure risk transmitter during the COVID-19 epidemic crisis, meaning it emits more shocks to the system than it receives. Additionally, it is interesting to note that Bitcoin is the most significant receiver and transmitter in the studied system. This result is consistent with the findings of Mnif et al.'s study (2022), which showed that all studied cryptocurrencies responded negatively to the pandemic and positively to the Russian invasion. They also found that Bitcoin was the least inefficient before the COVID-19 epidemic. They conclude that energy crisis caused by Russia has benefited the efficiency of the studied energy-efficient cryptocurrencies.

Table 6: Total static connectivity for Bitcoin, Gold, Wheat, Gas and WTI

	WTI	Wheat	Gas	Or	Bitcoin	FROM
WTI	97.34	1.04	1.34	0.11	0.16	2.66
Wheat	1.21	98.37	0.01	0.36	0.04	1.63
Gas	1.36	0.04	98.36	0.21	0.02	1.64

Or	0.15	0.17	0.25	99.15	0.28	0.85
Bitcoin	0.01	0.08	0.20	0.29	99.42	0.58
TO	2.73	1.34	1.81	0.98	0.51	7.36
Inc.Own	100.07	99.71	100.17	100.12	99.93	cTCI/TCI
NET	0.07	-0.29	0.17	0.12	-0.07	1.84/1.47
NPT	3.00	2.00	2.00	2.00	1.00	

	Bitcoin	Or	Wheat	Gas	WTI	FROM
Bitcoin	94.20	2.74	0.72	0.47	1.88	5.80
Or	2.89	95.17	1.17	0.15	0.63	4.83
Wheat	0.72	1.18	96.93	0.05	1.12	3.07
Gas	0.04	0.15	0.07	98.33	1.41	1.67
WTI	1.97	0.45	0.78	0.90	95.91	4.09
TO	5.62	4.52	2.73	1.56	5.04	19.47
Inc.Own	99.82	99.68	99.66	99.89	100.94	cTCI/TCI
NET	-0.18	-0.32	-0.34	-0.11	0.94	4.87/3.89
NPT	3.00	1.00	1.00	2.00	3.00	

	Or	WTI	Wheat	GAS	BTC	FROM
Or	77.76	14.77	3.10	0.60	3.77	22.24
WTI	13.57	72.10	8.48	3.47	2.38	27.90
Wheat	2.37	14.17	77.81	5.12	0.52	22.19
GAS	0.60	3.68	2.57	90.62	2.52	9.38
BTC	5.73	1.59	0.30	1.83	90.55	9.45
TO	22.28	34.22	14.45	11.03	9.19	91.16
Inc.Own	100.04	106.32	92.26	101.64	99.74	cTCI/TCI
NET	0.04	6.32	-7.74	1.64	-0.26	22.79/18.23
NPT	2.00	3.00	1.00	1.00	3.00	

Source: Authors

The dynamic analysis of connectivity reveals significantly important findings. It is noteworthy that connectivity has increased significantly during the pandemic, which refers to the period from the announcement of the global pandemic until the beginning of 2022. What is particularly remarkable is the absence of connectivity among the studied commodities during the year 2021 until the beginning of 2022 (two months before the war). Additionally, we observe that all commodities have heterogeneous statuses over time, but during the pandemic, gas and Bitcoin act as clear transmitters, while gold and oil act as net receivers of shocks. Furthermore, wheat remains a rather ambivalent asset.

During the Russian military actions in Ukraine, the study of connectivity reveals that wheat and Bitcoin receive more shocks from the system composed of the studied commodities than they emit. Consequently, both of them are net receivers on average. On the other hand, oil, gas, and gold are pure net transmitters as they emit more shocks than they receive from the system. This result is consistent with the study conducted by Saqib Farid et al. (2021), which found that during the crisis, stocks, gold, and oil emerged as the main contributors to volatility shocks in the system. Moreover, they demonstrated that natural gas transmits fewer volatility spillovers to other financial markets. Additionally, the results of the dynamic total connectivity study through graphs show that connectivity is significantly higher than that recorded during the pandemic and even more persistent, ranging from a minimum of 17% to a maximum of 25%.

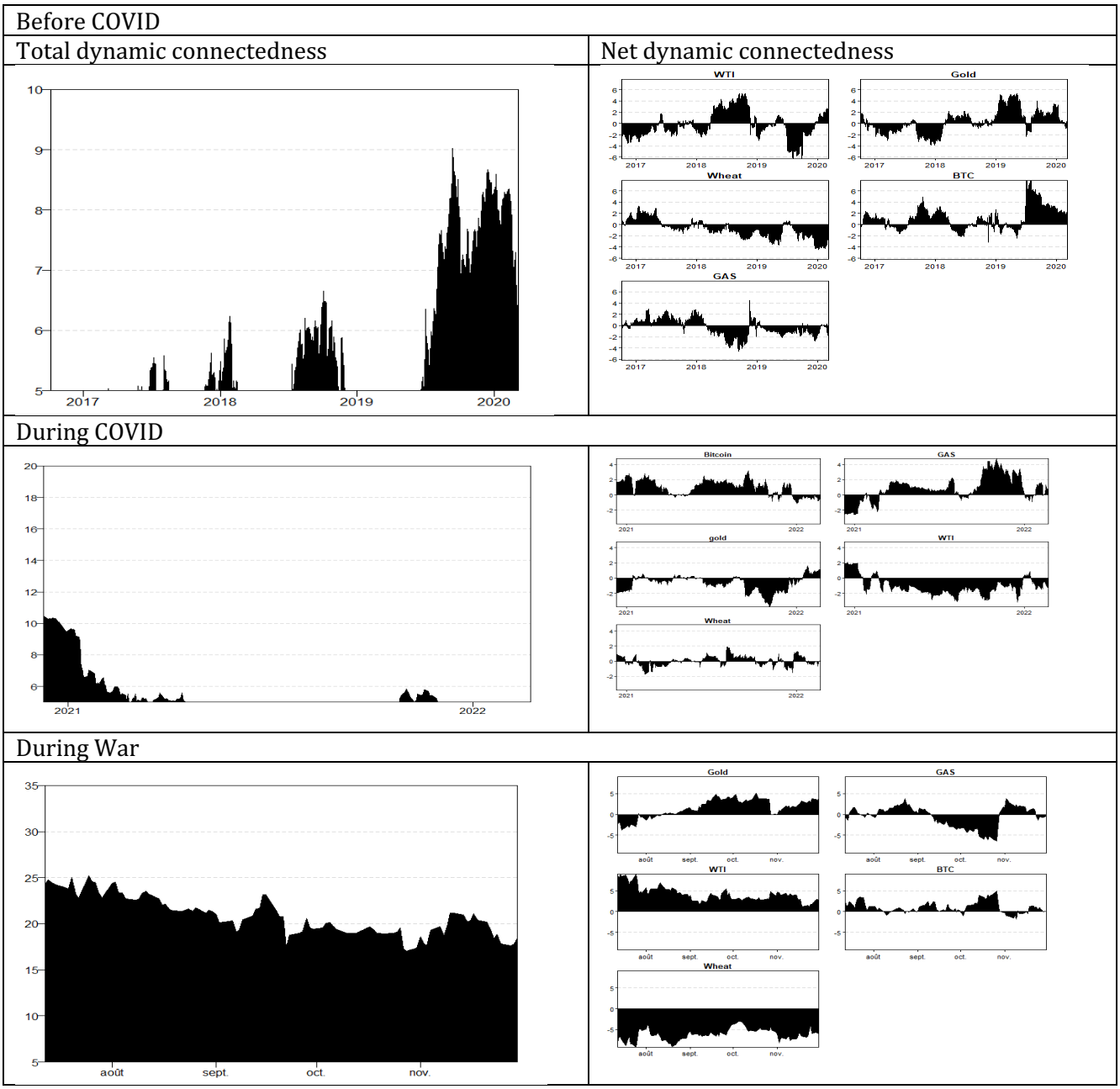


Figure 3: Dynamic total and net connectedness for Bitcoin, Gold, Wheat, Gas and WTI

Building upon these results, we can conclude that during periods of stability, oil, gas, and gold serve as means of diversification, while wheat and Bitcoin act as hedging instruments. Amidst the global COVID-19 pandemic, wheat, Bitcoin, gold, and gas can be considered safe havens, while oil remains the sole means of diversification. Furthermore, during the Russian military actions in Ukraine, in addition to oil, gas and gold become means of portfolio diversification, while wheat and Bitcoin can serve as hedging assets.

Returning to the results of the graphical representations regarding the dynamic status of net connectivity, gold clearly transitions from being a net receiver after the war announcement to becoming a net emitter towards mid-September. On the other hand, gas is generally a net emitter, except for the months of September and October. Conversely, oil is a net emitter, unlike wheat, which acts as a net receiver of shocks throughout the entire study period. Finally, Bitcoin is generally a net emitter, except for the first half of November.

This finding aligns with the results of F. Mensi et al. (2021), who examined the dynamic frequency connectivity for volatility differences among cryptocurrencies. They find that each cryptocurrency can act as a shock emitter or receiver. Moreover, Matkovskyy and Jalan (2019) demonstrated that the cryptocurrency market experiences shocks from financial markets. Their role is contingent upon temporal and frequency domains or their own past shocks and previous volatilities (Katsiampa, 2019). In conclusion, these findings shed light on the importance of connectivity and its impact on various assets during different periods and events. By understanding the dynamics of connectivity, investors can make informed decisions regarding diversification and hedging strategies.

5. CONCLUSION

The study on the connectivity between the stock indices of Gulf countries, commodities, and Bitcoin highlights several important key points. First, we find that the Russian military actions in Ukraine present a deeper impact in the GCC financial markets compared to the pandemic period. In fact, we noted greater volatility and inferior returns. Also, the results prove the contagion effect during unstable periods. We conclude that financial markets are tightly connected since shocks extent quickly among assets especially in crisis. A distinguished finding is that international stock markets are more impacted than commodity markets through deeper and more persistent fluctuations during unstable periods. Particularly, during the war, we note alterations of assets roles from being net shock receivers and net shock transmitters. During the pandemic, gold and Bitcoin are not significantly connected with the GCC stock indices. Nevertheless, during the military actions, we notice the permanent magnitude of shocks transmission and reception for gold and Bitcoin. This is very significant in terms of investment strategies. It shows that some commodities could help hedge or diversify investors' portfolios according to the studied and critical period. finally, we offer insights of the multifaceted dynamics of the connections amid Bitcoin and commodities prices and the financial assets since they alternate position between net risk receivers or transmitters. From a policy standpoint, these findings underscore the need for crisis-sensitive regulatory frameworks: GCC monetary authorities and financial supervisors should integrate dynamic connectedness analysis into systemic risk monitoring, tailor policy responses to shock type (e.g., health vs. geopolitical), and update investment guidelines for public funds to reflect the conditional hedging capacity of assets such as gold and Bitcoin—thereby fostering financial resilience that adapts to the evolving nature of global crises.

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Availability of data and materials

We obtained all the data from Datastream. No new data were created for this study

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Ethics Declarations

Competing interests: The authors declare no competing interests.

Availability of Data and Material

Data and material will be provided on request.

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