ΣΠΟΥΔΑΙ / SPOUDAI
Journal of Economics and Business
http://spoudai.org
University of Piraeus

Dynamic Conditional Correlations among Global Financial Assets before and after the Covid-19 outburst

Magdalini Charda[a] Konstantina Pendaraki[b]

[a]University of Patras, Greece
Email: m.charda@upatras.gr
[b]University of Patras, Greece
Email: dpendara@upatras.gr

Abstract

This study investigates the dynamic nexus among the main economic sectors, safe haven assets, and modern forms of investment before and during normal and stressed eras. The DCC-GARCH methodology is employed covering the pre-Covid period (4 January 2017 to 21 January 2022) and the Covid-19 period (22 January 2020 to 28 March 2023). Econometric outcomes reveal high levels of connectedness among stock sub-indices and this is more pronounced between Banks, Financials, Industrials, and Basic Materials which are stronger during the pandemic compared to normal conditions. Consumer Goods, Consumer Services, and Technology also display remarkable linkages with the remaining sectors. Gold and Bitcoin are found to be efficient diversifiers and weak hedgers in stock portfolios but with low statistical significance. Overall, bear markets are found to generate more intense herding phenomena than bull markets. This paper sheds light on the relations among traditional and modern forms of investments and help investors improve the risk-return trade-off in their portfolios.

JEL Classification: F3, F6, G1
Keywords: Sectoral Stock indices, Gold, Bitcoin, DCC-GARCH

1. Introduction

Financial crises have aroused increasing interest in a worldwide level due to the serious consequences they bring about in national economies and financial markets, and the large level of irregularities they cause in the connectedness of investment assets. The Global Financial Crisis that was initiated in 2008 has led to a voluminous bulk of academic work examining whether unconventional monetary policies could prove sufficient to prevent the recession from getting deeper (Neely, 2015, 2022; Meegan et al., 2018; Papadamou et al., 2018, 2019; 2020; Urbschat and Watzka, 2020). The recent pandemic-led crisis has revived

interest on how can stable overall economies and financial markets be considered and whether safe haven assets could prove to be efficient for preserving wealth and satisfactory income levels (Cheema et al., 2022).

This study investigates the dynamic correlations presented between a range of alternative investment assets that could be employed in order to optimize the risk-return trade-off in normal periods but also during crises. More specifically, the Dynamic Conditional Correlations (DCC- GARCH) methodology is adopted for investigating how they influence each other as time passes and to look into the relation that each of these assets displays with each of the remaining assets. In order for this research to provide a bird's-eye view on investing choices and offer a roadmap to interested investors in a global context, traditional financial assets of major importance such as sectoral stock indices and precious metals such as gold but also modern assets with increasing popularity such as cryptocurrencies are set under scrutiny.

The purpose of this study is to explore by which degree conventional investment assets e.g. gold and oil but also more modern assets such as cryptocurrencies could function as risk hedgers as defined by Baur and McDermott (2010) in portfolios consisting of well-established stocks. This examination will help investors calculate the optimal weights for their portfolios. To the best of our knowledge, this is the first study to set under investigation in a dynamic framework how such a full spectrum of investments like each one of the representative sectors of the economy, and the major representatives of precious metals and cryptocurrencies are linked with each other and provide diversifying or hedging tools against poor performance during crises.

The remainder of this paper is structured as follows. Section 2 provides the main findings of the relevant literature. Section 3 presents the data and methodology adopted. Section 4 lays out and analyzes the econometric findings and economic implications. Finally, Section 5 concludes and provides avenues for further research.

2. Literature review

A number of interesting studies have investigated the nexus among stock markets, commodities or cryptocurrencies. The first strand of literature related to this paper is about the relations among stock indices or their connection with other financial assets. Barunik et al. (2016) reveal tight linkages among economic sectors in the US and argue that negative spillovers are stronger than positive ones. Furthermore, Gamba-Santamaria et al. (2017) provide evidence that the Brazilian stock index causes volatility on stock markets of other Latin American countries and the US while Chile, Colombia, and Mexico receive more effects overall than they exert. When it comes to Tiwari et al. (2018), they support that stocks, bonds, credit default swaps and national currencies display only low connectedness among them.

Moreover, Ameur et al. (2020) argue that European markets are more vulnerable to systemic risk during bear markets whereas US markets are prone to risks from intense bull markets. Somewhat similarly, Kyriazis (2021) identifies weak positive nexus of European stock indices with crude oil and documents that the gold and oil markets are influential on major European equity sectors. Not far from this, Mensi et al. (2022) find that gold is not very influential on European stock indices and oil and that negative systemic impacts are stronger than positive ones and are intensified by the Covid-19 crisis. Bhatia et al. (2020) do not trace strong fluctuations in the connection between stock indices of the BRICS (Brazil, Russia, India, China, and South Africa) and advanced countries but reveal that palladium is the best

ingredient in a portfolio consisting of stocks while silver is the optimal hedger overall. Moreover, Yarovaya et al. (2021) argue that conventional assets and Islamic assets present more powerful relations when the Covid-19 pandemic starts and that gold and oil are significant determinants of this nexus while Bitcoin is not.

The second strand of relevant literature is about the linkages among precious metals or fuel or their relation with other assets. Poshakwale and Mandal (2016) argue that gold is not a suitable hedger in a portfolio consisting of real estate assets and oil but is a sufficient hedge against inflation. Additionally, Chemkha et al. (2021) support that gold and Bitcoin present very weak hedging abilities towards conventional assets during the Covid-19 period and Gonzalez et al. (2021) reveal that cryptocurrencies are more responsive to negative than to positive shocks.

Moreover, Mensi et al. (2021) support that platinum, palladium, and silver transmit significant effects towards the Australian dollar and the Canadian dollar. The British pound, the Euro and the Chinese yuan are net receivers of impacts overall. Al-Nassar et al. (2022) document that gold is the best hedger against Saudi Arabian investment assets during the pandemic while traditional assets could serve as diversifiers. Furthermore, Dai et al. (2022) support that stock markets generate large systemic effects while gold and oil are mostly receivers of systemic impacts while Gkillas et al. (2022) identify a stronger gold-Bitcoin nexus than the crude oil- Bitcoin nexus.

As concerns the third relevant strand of research, the correlations among cryptocurrencies or between them and alternative assets are examined. Klein et al. (2018) confirm that Bitcoin is a significantly inferior hedger than gold during crises whereas Selmi et al. (2018) argue that Bitcoin as well as gold can serve as diversifiers or hedgers against fluctuations in oil market values and during elevated economic uncertainty in the US. Guesmi et al. (2019) support that Bitcoin, gold, oil and stock markets can prove to be very useful for lowering risk in portfolios.

Beneki et al. (2019) reveal the tight hedging connection between Bitcoin and Ethereum which is more pronounced concerning their volatilities but fades out as time progresses. As concerns the nexus of Bitcoin with commodities, Symitsi and Chalvatzis (2019) detect very low levels of such linkages and that the usefulness from these hedging capabilities is more obvious during crises. Not far from that, Yang et al. (2022) estimate that only weak connection of Bitcoin with commodities exists in the short-run whereas this cryptocurrency is found to be the besthedger in the long-run.

3. Data and Methodology

Estimations take place for two sub periods (before the Covid-19 and during the Covid-19) in order to conduct comparisons of how financial assets behave during normal periods versus crises. The periods examined span the pre-Covid era (4 January 2017 to 21 January 2022) and the Covid-19 era (22 January 2020 to 28 March 2023). For the purposes of covering the global financial markets to a satisfactory extent, this paper has adopted data about eleven different economic sectors as expressed by the highly representative Dow Jones index constituents. To be more precise, the DJ Banks, the DJ Basic Materials, the DJ Consumer Goods, the DJ Consumer Services, the DJ Financials, the DJ Health Care, the DJ Industrials, the DJ Oil & Gas, the DJ Real Estate, the DJ Technology, and the DJ Utilities stock indices are used for estimations. Moreover, gold prices (expressed in US dollars) are downloaded in order to represent the markets of precious metals that serve as safe havens during crises. Apart from these, this study employs the Bitcoin market values (also expressed in dollars) for examining whether modern forms of investment could be a remedy for the large losses that

traditional assets could probably display during bear markets. All data are downloaded in daily closing prices from the Yahoo Finance website. The latter is among the most popular and reliable sources in academic work in the field of finance. All data are transformed into logarithmic differences to express the returns of variables and for variables to become stationary.

Figure 1 presents the time evolution of market values concerning sectoral stock indices, gold, and Bitcoin. It should be noted that values of stock indices are mostly stable during normal periods while present an abrupt decrease during March 2020 when the outbreak of a large number of deaths due to Covid-19 takes place in a worldwide level. Just after this event, the recovery phase in traditional stock markets can be observed while new tendencies for bear markets are depicted since early 2022 due to the beginning of the Russian-Ukrainian war. It should be emphasized that gold does not follow the same pattern with stock indices as crises have a positive effect on its market values due to its safe haven character. Bitcoin also presents different behaviour from stock indices as the Covid-19 outbreak in 2020 is not influential for its market values as this cryptocurrency had already been in a bear market since 2018. Notably, Bitcoin displays tremendous growth in prices since the optimistic news about the Covid-19 disease appeared. Therefore, since December 2020 a strong bull Bitcoin market has made its appearance but bear tendencies have emerged since the summer of 2021.

When it comes to the examination of the returns of the variables investigated, they are illustrated in Figure 2 and provide some interesting findings. Overall, it can be seen that the levels of fluctuations during the Covid-19 crisis have been significantly more elevated in comparison to normal times. It goes beyond doubt that the highest levels of volatility make their appearance during March 2020 when the burst in Covid-19 deaths takes place. It should be emphasized that Bitcoin exhibits the highest levels of fluctuations and this confirms its unstable character. On the contrary, gold is found to be the most stable among the assets examined and this abides by its safe haven character. It should be observed that the Russia-Ukraine conflict (2022 and early 2023) is responsible for higher levels of instability than the second phase of the Covid-19 crisis (2021).

It is revealed by the descriptive statistics as displayed in Table 1 that stock sectors (with the exception of the Technology sector) present low levels of variance in relation to their mean. The same is valid about gold which is also considered to be a traditional financial asset. On the contrary, Bitcoin is found to be very volatile. It should be noted that all variables (with the exceptionof Banks) suffer from non-normality as indicated by the Jarque-Bera statistic.

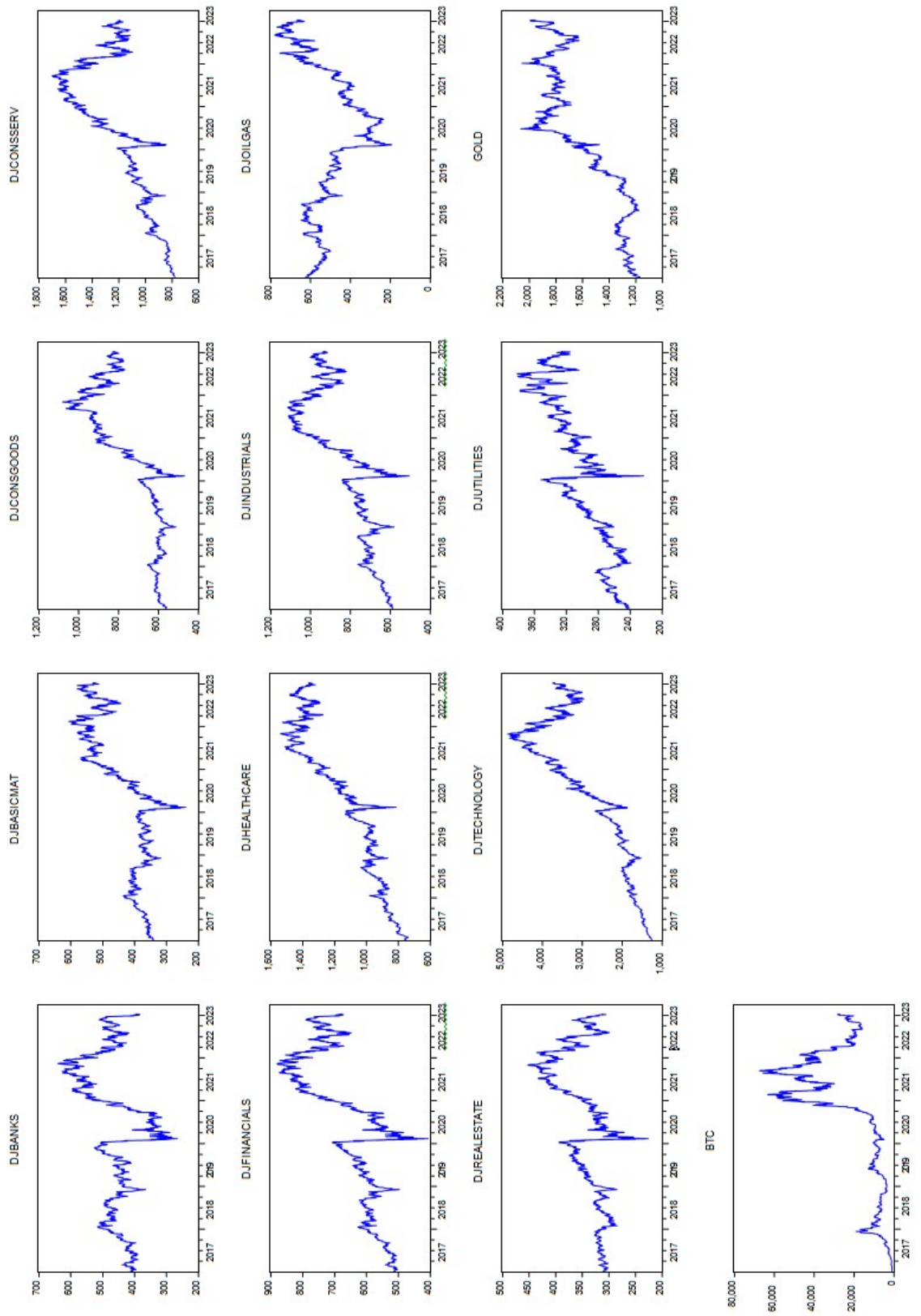

Figure 1. Market values of sectoral indices, gold, and Bitcoin during the whole period

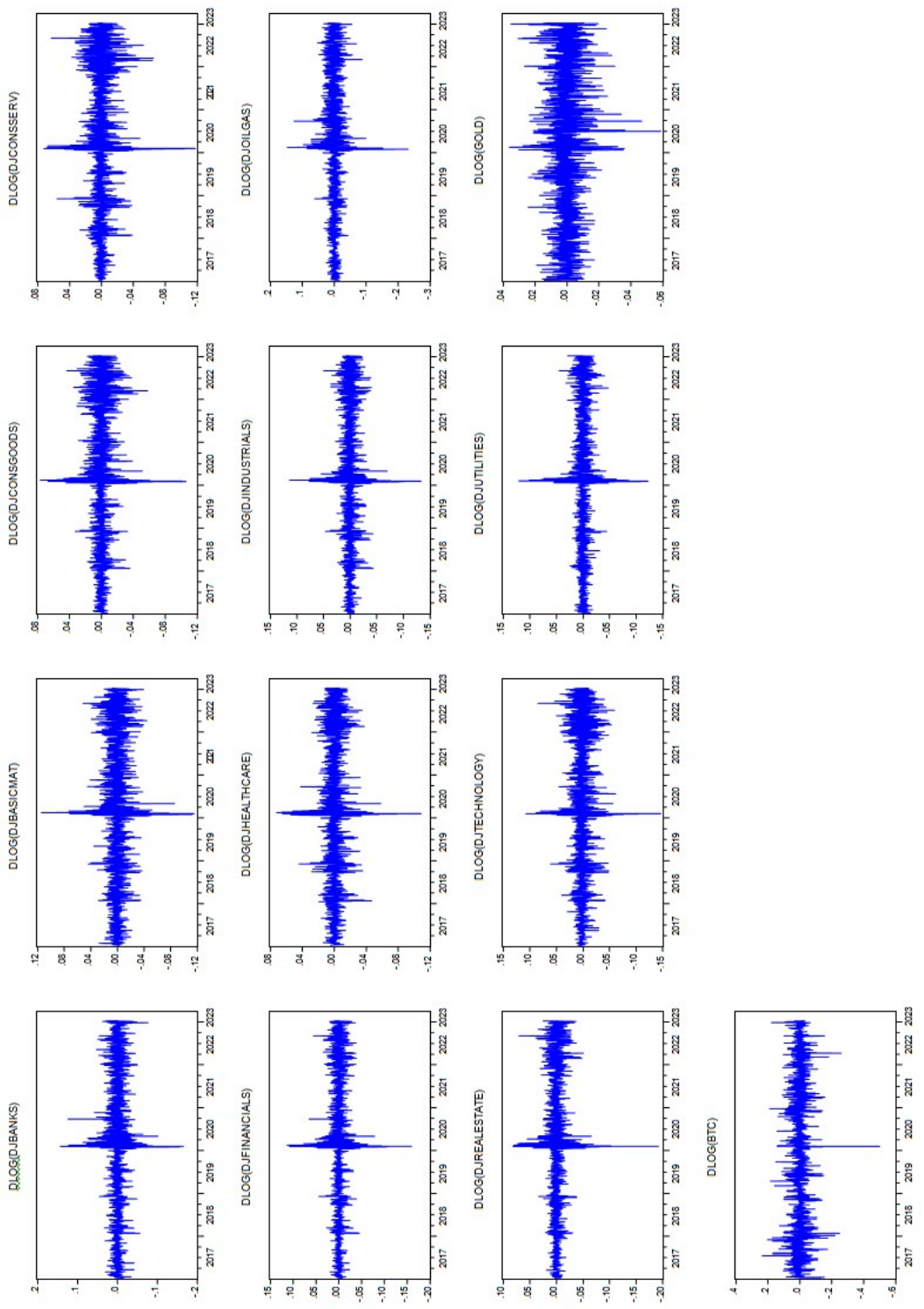

Figure 2. Returns of sectoral indices, gold, and Bitcoin during the whole period

Table 1: Descriptive statistics

	Mean	Max	Min	Std.Dev.	Skewness	Kurtosis	Jarque-Bera
DJBanks	460.91	638.54	263.42	70.82	0.05	2.95	0.93
DJBasMat	431.87	605.86	239.69	78.75	0.46	1.94	127.90***
DJConsGoods	725.87	1079.69	469.67	147.04	0.57	1.85	171.01***
DJConsServ	1167.52	1704.10	775.90	255.12	0.43	2.10	102.41***
DJFinancials	649.21	880.45	404.13	104.94	0.50	2.12	115.59***
DJHealthCare	1122.77	1540.53	734.05	228.49	0.21	1.60	139.37***
DJIndustrials	819.49	1118.69	504.20	152.89	0.40	1.93	115.46***
DJOilGas	514.61	784.57	193.83	124.85	-0.35	2.62	41.24***
DJRealEstate	344.06	453.47	226.28	39.48	0.69	2.74	129.45***
DJTechnology	2684.16	4866.70	1252.40	1001.43	0.40	1.83	131.25***
DJUtilities	301.61	382.09	223.24	34.42	0.14	2.03	66.51***
Gold	1561.94	2063.19	1163.80	263.04	-0.01	1.38	171.25***
Bitcoin	17821.23	67527.90	778.60	16472.94	1.19	3.24	373.99***

Moreover, the Augmented Dickey Fuller (ADF) test is conducted in order to check for the existence of a unit root. Findings reveal the existence of a unit root in levels but no unit root problem arises when estimations are made with logarithmic differences of the variables. Furthermore, the ARCH test takes place in order to test for heteroskedasticity. It is found that heteroskedasticity exists so GARCH-based methodologies should be applied for achieving reliable results.

Table 2: Tests for unit root and heteroskedasticity

	ADF test (levels)	**ADF test (logarithmic differences)**	**ARCH test**
DJBanks	-2.2688	13.6957***	187.5478***
DJBasMat	-1.5137	-12.7558***	71.1798***
DJConsGoods	-1.4197	-11.5834***	138.2129***
DJConsServ	-1.6934	-12.6448***	145.1595***
DJFinancials	-2.0267	-11.9011***	273.4503***
DJHealthCare	-1.4401	-12.8495***	218.1052***
DJIndustrials	-1.7246	-11.9428***	162.9480***
DJOil&Gas	-1.3669	-12.8634***	34.0029***
DJRealEstate	-2.5915	-11.9550***	134.5215***
DJTechnology	-1.1797	-12.9461***	123.6905***
DJUtilities	-2.5737	-11.7788***	361.9481***
Gold	-1.1073	-38.5450***	6.7239***
Bitcoin	-1.4561	-41.3937***	14.9218***

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

The methodology employed for the purposes of our estimations is the Dynamic Conditional Correlations (DCC) approach based on Engle (2002). This methodology enables the examination of the linkages among financial assets in a dynamic rather than a static manner and lets us examine how interrelations are formed as time passes. More specifically, Engle (2002) suggested that time-varying conditional correlations ($q_{ij,}$) as displayed by formula (1) about two return series should be estimated by a GARCH (1,1) process that is based on Engle (1982) and Bollerslev (1986).

$$q_{ij,t} = \hat{\rho_{iy}} + \alpha_{dcc}\left(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \hat{\rho_{iy}}\right) + \beta_{dcc}\left(q_{ij,t} - \hat{\rho_{iy}}\right) \quad (1)$$

The correlation estimator is defined as in (2):

$$\rho_{ij,t} = \frac{q_{ij,t}}{q_{i,t}q_{j,t}} \quad (2)$$

and $\hat{\rho_{iy}}$ represents unconditional correlation between $\varepsilon_{i,t}$ and $\varepsilon_{j,t}$

Such methodologies have been previously employed by studies about major financial assets, such as in Kryzanowski et al. (2017), Benlagha and El Omari (2022) and Rai and Garg (2022). The major advantage of this methodology is that it combines the GARCH models, which are very popular in financial economics, with the DCC specification, which corresponds to a dynamic character. The latter helps in better estimation of the relation among variables as time evolves and not only on average, according to the bibliography. The DCC-GARCH methodology has been employed in high-quality academic research in order to find dynamic interconnectedness among economic or financial variables and is extremely popular for assessing the systemic linkages by a dynamic perspective as in Zhang et al. (2022).

4. Econometric outcomes

A range of useful econometric outcomes come to the surface concerning three alternative scenarios (only stock indices, stock indices and gold, stock indices and Bitcoin) in the pre-Covid-19 period. The same procedure is repeated as regards the Covid-19 period. This allows some very informative comparisons of findings between periods. Table 3 illustrates the results regarding the pre-Covid-19 period while Table 4 presents the findings about the Covid-19 period.

In Table 3.1., it can be seen that DJ Banks shows the highest dynamic correlation with DJ Financials while the lowest correlation with DJ Real Estate and DJ Utilities before the Covid-19.This connection is higher in most cases when Bitcoin is included in estimations. It should be noted that Bitcoin is a strong diversifier of DJ Banks while gold is a reliable hedger. Apart from estimations before the outbreak of the pandemic, econometric procedures about the Covid-19 period have taken place concerning all three scenarios. More specifically, the tight connection between DJ Banks and DJ Financials is confirmed (which is slightly higher than before the pandemic). It should be noted that gold serves a strong diversifier rather than a hedger so this contradicts findings before the Covid-19.

Table 3.1: Econometric outcomes by DCC-GARCH about DJBanks in alternative scenarios before the Covid-19

	Pre Covid19			Covid19		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJBanks, DJBasMat)	0.5967***	0.5877***	0.5987***	0.7303***	0.7316***	0.7335***
Corr(DJBanks, DJCondGoods)	0.4062***	0.4066***	0.4109***	0.5530***	0.5552***	0.5590***
Corr(DJBanks, ConsServ)	0.5823***	0.5763***	0.5830***	0.5562***	0.5579***	0.5608***
Corr(DJBanks, DJFinancials)	0.8966***	0.8950***	0.8975***	0.9041***	0.9046***	0.9056***
Corr(DJBanks, DJHealthCare)	0.4549***	0.4522***	0.4567***	0.4672***	0.4646***	0.4740***
Corr(DJBanks, DJIndustrials)	0.6555***	0.6493***	0.6574***	0.7445***	0.7457***	0.7487***
Corr(DJBanks, DJOil&Gas)	0.4632***	0.4519***	0.4737***	0.6544***	0.6555***	0.6544***
Corr(DJBanks, DJRealEstate)	0.1043**	0.1110**	0.1110**	0.5436***	0.5424***	0.5516***
Corr(DJBanks, DJTechnology)	0.4891***	0.4827***	0.4905***	0.4131***	0.4131***	0.4211***
Corr(DJBanks, DJUtilities)	-0.0896*	-0.0709	-0.0845*	0.4091***	0.4051***	0.4155***
Corr(DJBanks, Gold)		-0.2936			0.0151	
Corr(DJBanks, Bitcoin)			0.0340			0.0153

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Moreover, Table 3.2. shows that DJ Basic Materials has the highest connection with DJ Industrials whereas presents the weakest linkages with the DJ Utilities sector. In resemblance with the case of DJ Banks, gold is a hedger while Bitcoin is a trustworthy diversifier against DJ Basic Materials. Moreover, it can be seen that the DJ Basic Materials sector continues to be mostly linked with the DJ Industrials and the DJ Financials sectors. Nevertheless, their connection is significantly higher during the disease. The DJ Utilities sector keeps being the least connected sector. Apart from this, gold has been transformed into a strong diversifier instead of a hedger.

Table 3.2: Econometric outcomes by DCC-GARCH about DJBasicMaterials in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJBasMat, DJConsGoods)	0.6004***	0.5946***	0.6020***	0.6932***	0.6924***	0.6967***
Corr(DJBasMat, DJConsServ)	0.6376***	0.6306***	0.6404***	0.6882***	0.6884***	0.6904***
Corr(DJBasMat, DJFinancials)	0.6882***	0.6810***	0.6897***	0.8442***	0.8442***	0.8459***
Corr(DJBasMat, DJHealthCare)	0.5557***	0.5497***	0.5563***	0.6436***	0.6413***	0.6474***
Corr(DJBasMat, DJIndustrials)	0.7957***	0.7919***	0.7981***	0.8810***	0.8813***	0.8825***
Corr(DJBasMat, DJOil&Gas)	0.5789***	0.5723***	0.5864***	0.6676***	0.6664***	0.6688***
Corr(DJBasMat, DJRealEstate)	0.2590***	0.2586***	0.2633***	0.6617***	0.6592***	0.6665***
Corr(DJBasMat, DJTechnology)	0.5958***	0.5907***	0.5988***	0.6102***	0.6087***	0.6137***
Corr(DJBasMat, DJUtilities)	0.0469	0.0549	0.0501	0.5206***	0.5159***	0.5257***
Corr(DJBasMat, Gold)		-0.0496			0.0508	
Corr(DJBasMat, Bitcoin)			0.0212			0.0296

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Furthermore, Table 3.3. presents the DJ Consumer Goods to be mostly connected with the DJ Industrials and to have the weakest linkages with the DJ Utilities sector. Similarly to previous sectors analyzed, there are small differences among the three scenarios considered. It should be noted that both gold and Bitcoin are hedgers against DJ Consumer Goods before the pandemic. When it comes to the case of DJ Consumer Goods during the pandemic, once more it is shown that including Bitcoin in the estimations increases the level of connection. Furthermore, the linkages are stronger during the Covid-19. Both gold and Bitcoin act as diversifiers due to the very low degree of connection with this sector.

Table 3.3: Econometric outcomes by DCC-GARCH about DJConsumerGoods in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJConsGoods, DJConsServ)	0.6610***	0.6597***	0.6628***	0.7989***	0.7995***	0.8005***
Corr(DJConsGoods, DJFinancials)	0.6220***	0.6221***	0.6257***	0.7288***	0.7307***	0.7328***
Corr(DJConsGoods, DJHealthCare)	0.5905***	0.5865***	0.5923***	0.6954***	0.6944***	0.6995***
Corr(DJConsGoods, DJIndustrials)	0.6792***	0.6756***	0.6808***	0.7992***	0.8003***	0.8016***
Corr(DJConsGoods, DJOil&Gas)	0.3544***	0.3491***	0.3627***	0.4194***	0.4166***	0.4192***
Corr(DJConsGoods, DJRealEstate)	0.5570***	0.5551***	0.5593***	0.6768***	0.6786***	0.6815***
Corr(DJConsGoods, DJTechnology)	0.5413***	0.5423***	0.5483***	0.7605***	0.7611***	0.7633***
Corr(DJConsGoods, DJUtilities)	0.3983***	0.4003***	0.4000***	0.5583***	0.5559***	0.5652***
Corr(DJConsGoods, Gold)		-0.0954*			0.0046	
Corr(DJConsGoods, Bitcoin)			-0.0396			0.0025

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Table 3.4. reveals that findings are similar about the DJ Consumer Services sector. The DJ Industrials are the sector with the tightest linkages while DJ Financials follow. Including gold in the portfolio slightly lowers the connection while including Bitcoin slightly increases it. Moreover, in the case of DJ Consumer Services during the Covid-19, the disease and Bitcoin are found to increase the level of connection. Utilities remain the sector which is the most irrelevant with this index. Gold and Bitcoin serve as diversifiers. It should be emphasized that this is in contrast to findings before the Covid-19 when both served as hedgers.

Table 3.4: Econometric outcomes by DCC-GARCH about DJConsumerServices in alternative scenarios before the Covid-19

	Pre-Covid19			Covid19		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJConsServ, DJFinancials)	0.7375***	0.7343***	0.7388***	0.7494***	0.7503***	0.7519***
Corr(DJConsServ, DJHealthCare)	0.6501***	0.6466***	0.6532***	0.6713***	0.6711***	0.6744***
Corr(DJConsServ, DJIndustrials)	0.7794***	0.7749***	0.7816***	0.8211***	0.8216***	0.8226***
Corr(DJConsServ, DJOil&Gas)	0.4792***	0.4716***	0.4895***	0.4129***	0.4114***	0.4113***
Corr(DJConsServ, DJRealEstate)	0.3828***	0.3866***	0.3873***	0.6958***	0.6970***	0.6987***
Corr(DJConsServ, DJTechnology)	0.7849***	0.7832***	0.7868***	0.8576***	0.8584***	0.8594***
Corr(DJConsServ, DJUtilities)	0.1104**	0.1217**	0.1119**	0.4884***	0.4861***	0.4932***
Corr(DJConsServ, Gold)		-0.1296***			0.0262	
Corr(DJConsServ, Bitcoin)			-0.0217			0.0323

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

In Table 3.5.the DJ Financials are mostly linked with the DJ Industrials and this is a bit more emphasized when Bitcoin is included in estimations. Gold is found to be a hedger but Bitcoin is a strong diversifier against DJ Financials. When it comes to the Financials sector during the pandemic, it still is strongly linked with the Industrials sector but the linkages are tighter during the Covid-19. It should be mentioned that gold loses its hedging capacities during the disease and becomes a strong diversifier.

In the case of DJ Health Care, in Table 3.6., the lowest relation is found to exist with the DJ Utilities and the DJ Oil & Gas follow. Gold is a stronger hedger against DJ Health Care than Bitcoin. As concerns the DJ Health Care sector during the Covid-19, it is revealed to be strongly connected with the DJ Industrials sector and this is emphasized when the Bitcoin is included in estimations. It should be stressed that during the Covid-19 both gold and Bitcoin become powerful diversifiers and this contradicts the results before the Covid-19 where both acted as hedgers.

Table 3.5: Econometric outcomes by DCC-GARCH about DJFinancials in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**With Gold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJFinancials, DJHealthCare)	0.6391***	0.6373***	0.6414***	0.6857***	0.6830***	0.6903***
Corr(DJFinancials, DJIndustrials)	0.8126***	0.8089***	0.8137***	0.9128***	0.9129***	0.9141***
Corr(DJFinancials, DJOilGas)	0.5011***	0.4927***	0.5118***	0.6551***	0.6546***	0.6540***
Corr(DJFinancials, DJRealEstate)	0.4285***	0.4342***	0.4325***	0.7943***	0.7932***	0.7981***
Corr(DJFinancials, DJTechnology)	0.6568***	0.6545***	0.6594***	0.6383***	0.6377***	0.6429***
Corr(DJFinancials, DJUtilities)	0.1459***	0.1602***	0.1492***	0.6002***	0.5968***	0.6048***
Corr(DJFinancials, Gold)		-0.2379***			0.0324	
Corr(DJFinancials, Bitcoin)			0.0154			0.0233

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Table 3.6: Econometric outcomes by DCC-GARCH about DJHealthCare under alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJHealthCare, DJIndustrials)	0.6741***	0.6705***	0.6765***	0.7431***	0.7406***	0.7453***
Corr(DJHealthCare, DJOilGas)	0.4023***	0.4010***	0.4109***	0.3606***	0.3562***	0.3605***
Corr(DJHealthCare, DJRealEstate)	0.4224***	0.4222***	0.4257***	0.6804***	0.6801***	0.6847***
Corr(DJHealthCare, DJTechnology)	0.6333***	0.6312***	0.6387***	0.6905***	0.6896***	0.6936***
Corr(DJHealthCare, DJUtilities)	0.2604***	0.2654***	0.2624***	0.5967***	0.5940***	0.6023***
Corr(DJHealthCare, Gold)		-0.0984*			0.0245	
Corr(DJHealthCare, Bitcoin)			-0.0054			0.0348

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Moreover, in Table 3.7.it is presented that DJ Industrials are tightly linked with the DJ Technology sector. This connection weakens when gold is included while gets stronger when Bitcoin is included. It should be noticed that gold acts as a hedger while Bitcoin has almost no connection with the DJ Industrials sector. By examining the Covid-19 period, gold is found once again to slightly reduce the connection while Bitcoin increases it. It is noteworthy that gold becomes a diversifier rather than a hedger that it used to be before the pandemic.

Table 3.7: Econometric outcomes by DCC-GARCH about DJIndustrials in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**With Gold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJIndustrials, DJOil&Gas)	0.5571***	0.5507***	0.5665***	0.6037***	0.6020***	0.6036***
Corr(DJIndustrials, DJRealEstate)	0.3632***	0.3655***	0.3665***	0.7759***	0.7754***	0.7795***
Corr(DJIndustrials, DJTechnology)	0.7404***	0.7381***	0.7437***	0.7486***	0.7477***	0.7502***
Corr(DJIndustrials, DJUtilities)	0.1219**	0.1308***	0.1237***	0.6055***	0.6026***	0.6090***
Corr(DJIndustrials, Gold)		-0.1534***			0.0360	
Corr(DJIndustrials, Bitcoin)			0.0021			0.0275

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Table 3.8. shows that the DJ Oil & Gas sector has extremely low connection with the DJ Utilities sector. Gold is a hedger but Bitcoin has very low positive connection with this index. The DJ Oil & Gas sector does not have close relation with the sectors examined during the Covid-19. Moreover, gold preserves the role of hedger and Bitcoin keeps the role of strong diversifier just as in the pre-Covid-19 period.

Notably, gold becomes a strong diversifier while Bitcoin is a weak hedger regarding DJ Real Estate as can be seen in Table 3.9. Moreover, DJ Real Estate is revealed to have a modest nexus with other sectors during the pandemic. Notably, Bitcoin becomes a powerful diversifier while used to be a hedger before the pandemic.

Table 3.8: Econometric outcomes by DCC-GARCH about DJOil&Gas in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJOil&Gas, DJRealEstate)	0.1637***	0.1675***	0.1681***	0.4210***	0.4179***	0.4264***
Corr(DJOil&Gas, DJTechnology)	0.4235***	0.4194***	0.4348***	0.3334***	0.3286***	0.3343***
Corr(DJOil&Gas, DJUtilities)	0.0025	0.0160	0.0043	0.3089***	0.3052***	0.3126***
Corr(DJOil&Gas, Gold)		-0.0226			-0.0085	
Corr(DJOil&Gas, Bitcoin)			0.0018			0.0425

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Table 3.9: Econometric outcomes by DCC-GARCH about DJOilGas in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**WithGold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corr(DJRealEstate, DJTechnology)	0.3206***	0.3238***	0.3263***	0.6226***	0.6230***	0.6255***
Corr(DJRealEstate, DJUtilities)	0.5846***	0.5795***	0.5856***	0.7156***	0.7155***	0.7192***
Corr(DJRealEstate, Gold)		0.0317			0.0453	
Corr(DJRealEstate, Bitcoin)			-0.0303			0.0269

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Similar findings can be seen in Table 3.10. about the DJ Technology sector. Notably though, gold becomes a diversifier and Bitcoin acts as a hedger in the case of the DJ Utilities sector. Finally, it is found that gold and Bitcoin switch roles as diversifiers or hedgers with respect to the DJ Technology and the DJ Utilities in relation to the period before the pandemic.

Table 3.10: Econometric outcomes by DCC-GARCH about DJTechnology and DJUtilities in alternative scenarios before the Covid-19

	Pre-Covid19			**Covid19**		
	Basic	**With Gold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Corre(DJTechnology, DJUtilities)	0.0791	0.0865*	0.0824*	0.4089***	0.4066***	0.4141***
Corr(DJTechnology, Gold)		-0.1050**			0.0160	
Corr(DJTechnology. Bitcoin)			0.0152			-0.0192
Corr(DJUtilities, Gold)		0.0617			-0.0019	
Corr(DJUtilities, Bitcoin)			-0.0342			0.0185

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Moreover, it should be emphasized that in Table 3.11., the sum of the Lambda1 and the Lambda2 coefficients equals to less than 1 in each of the three scenarios under consideration. This reveals that the estimations conducted by the DCC-GARCH framework abide by the constraint that these two factors do not exceed unity. This gives credence to the notion that the econometric estimations that have taken place here are trustworthy.

Table 3.11: Lambda values of estimations

	Pre-Covid19			**Covid19**		
	Basic	**With Gold**	**With Btc**	**Basic**	**WithGold**	**With Btc**
Lambda1	0.0187***	0.0173***	0.0158***	0.0228***	0.0193***	0.0227***
Lambda2	0.9346***	0.9410***	0.9378***	0.8642***	0.8786***	0.8403***

Note: *, **, *** stand for statistical significance of estimations at the 90%, 95%, and 99% levels, respectively.

Overall, the econometric findings reveal that dynamic conditional connectedness among sectoral stock indices, gold, and Bitcoin is evident during normal periods. Banks display the highest dynamic correlation (0.8966) with the Financials sector before the crisis at the basic scenario while also abides by the scenario with gold (0.8950) and the scenario with Bitcoin (0.8975). Nevertheless, Banks present very low dynamic correlation with the Real Estate sector (0.1043) in the pre-Covid era.

Moreover, results from estimations show that the dynamic nexus among sectoral stock indices, gold, and Bitcoin during the Covid-19 pandemic is notably elevated in comparison with normal times. The Banks – Financials linkages continue to be the most intense and they are found to slightly increase (0.9041) during the Covid-19 at all three scenarios. It should be noted that the relation of Banks with the Real Estate sector becomes much stronger (0.5436) during the pandemic.

All in all, sectors of major importance such as the Banks, the Financials, and the Industrials

are found to be more affected by systemic risk (they exhibit higher dynamic correlations with almost all assets) during the intense Covid-19 bear tendencies in markets while before the disease a modest to slightly high nexus (approximately 0.60 on average) with other sectors is revealed. Interestingly, the Real Estate sector presents a surprisingly high increase in the level of connection with the remaining assets during the pandemic than before and the Oil&Gas and the Utilities sectors follow also with very sizable alterations. By an economic viewpoint, this means that these sectors are greatly affected by the overall financial markets during stressed eras but are primarily autonomous in normal periods. It should also be noted that gold serves as a weak hedger against conventional markets while Bitcoin is a very strong diversifier regarding them. Remarkably, these capabilities become slightly weaker during the pandemic and it is surprising that safe haven phenomena fade away instead of intensifying during crises. Estimations about gold and Bitcoin are not statistically significant in both sub periods in the majority of cases while findings about stock sectors are statistically very trustworthy.

6. Conclusions

This paper sets under investigation the dynamic connectedness between sectoral stock indices as expressed by the Dow Jones sub-indices, the major precious metal (gold) that is considered to be the best safe haven and the major cryptocurrency (Bitcoin) which becomes increasingly popular to profit-hungry investors. Examination takes place before and during the Covid-19 pandemic by employing the advanced DCC-GARCH specification with alternative scenarios of only stock indices or the inclusion of gold or Bitcoin in portfolios.

Findings reveal very strong connectedness among the Banks, Financials, and Industrials sectors and between them and modest to high relation with alternative sectors (Real Estate being the outstanding exception) which significantly increases during Covid-19 in relation to normal periods. Real Estate, Oil&Gas as well as the Utilities display very weak relation with the system before Covid-19 as they act very autonomously while significantly larger during the crisis due to the high influence exerted by overall bear tendencies. Gold is revealed to be a weak hedging tool and Bitcoin a strong diversifying asset but these abilities slightly weaken in stressed eras and results are not statistically reliable. This provides credence to the notion that no efficient defense against losses due to market crash can be generated in special (stressed) conditions. The weak hedging capacities of gold corroborate the findings of Chemhka et al. (2021) while Bitcoin being a diversifier only partly abides with Huang et al. (2023) that reveal that it is mainly a hedger.

This is the first study to dynamically examine how such a large array of investments like every one of the representative economic sectors, and the most important and popular precious metals, and cryptocurrencies are connected with each other and serve for diversification or hedging against potential losses during bear markets. This paper informs the interested reader about the linkages among a range of financial assets in order to provide a compass for the amelioration of the risk-return trade-off during normal periods versus crises by tracing the special influence that assets can exert between each pair. Avenues for further research should include the thorough investigation of a wider array of traditional and sophisticated assets with advanced methodologies about dynamic spillovers.

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