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Economic Virus in Our Body Cells: To What Extent Are Gold Prices Immune Against Sectoral Stock Indexes?

Vücut Hücrelerimizdeki Ekonomik Virüs: Altın Fiyatları Sektörel Borsa Endeklerine Ne Derece Bağışık?

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ÖZ

Yeni koronavirüs (COVID-19), yalnızca küresel finansal piyasalarda değil, aynı zamanda emtia piyasalarında da derin ve orantısız etkiler ortaya koymuştur. Altının ekonomik çalkantılara ve belirsizliklere karşı önemli bir emtia olarak potansiyel güvenli liman rolü dikkate alınarak; bu çalışmada 10.03.2020-22.03.2021 örneklem dönemi için COVID-19 ile ilişkili değişkenlerin (dünyada ve ABD'de günlük yeni vaka sayıları, COVID-19 Containment & Health Endeksi) ve farklı makro-finansal faktörlerin günlük COMEX altın vadeli işlem kontrat fiyatları üzerindeki uzun vadeli etkilerinin ve kısa vadeli dinamiklerinin, Gecikmesi Dağıtılmış Otoregresif (ARDL) yaklaşım kullanılarak ve S&P 500 ve Dow Jones ile ilişkili çeşitli sektörel borsa endeksleri (Sağlık Hizmeti, Teknoloji, Tıbbi Malzeme, Finans, Sanayi, Bilgi Teknolojisi ve Enerji) bakımından karşılaştırmalı analizinin sunularak araştırılması amaçlanmıştır. Analiz sonuçları, altın fiyatlarının en çok hangi faktörlerden ve sektörel hisse senetlerinden etkilendiğine dair önemli politika çıkarımlarının oluşturulmasında büyük önem taşımaktadır. Sonuç olarak; Dow-Jones Finans, S&P 500 Sanayi ve S&P 500 Enerji hisse senedi endekslerinin uzun dönemde %10 anlamlılık düzeyinde altın fiyatları üzerinde anlamlı bir etki yarattığı söylenebilir. Bu endeksleri içeren modellerde WTI petrol fiyatlarının altın fiyatları üzerinde hiçbir etkisi bulunmazken CBOE volatilite endeksi altın fiyatlarını ters yönde etkilemektedir. Uzun dönemde katsayı anlamlılıkları açısından en zayıf bulgular S&P 500 Enerji hisse senedi endeksi getirilerini içeren model için elde edilmiştir. Ayrıca ABD'deki günlük yeni vakaların aksine dünyadaki günlük yeni vakalar genel olarak altın fiyatlarını etkilemektedir.

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ABSTRACT

The novel coronavirus (COVID-19) has revealed profound and disproportionate effects not only on global financial markets but also on commodity markets. Considering the potential safe-haven role of gold as a vital commodity against economic turmoils and uncertainties; in this study, it has been aimed to investigate the long run impacts and short-run dynamics of the COVID-19 related variables (daily new confirmed cases in the world and U.S., COVID-19 Containment & Health Index) and different macro-financial factors on daily COMEX gold futures contracts prices, especially presenting a comparative analysis with respect to various sectoral stock indexes associated with S&P 500 and Dow Jones -including Health Care, Technology, Medical Equipment, Financials, Industrials, Information Technology and Energy sectors- for the sample period 10.03.2020-22.03.2021 by utilizing from Autoregressive Distributed Lag (ARDL) approach. Analysis results are of great importance in forming crucial policy implications about by which factors and sectoral stocks gold prices are being influenced the most. Consequently; Dow-Jones Financials, S&P 500 Industrials and S&P 500 Energy stock indexes can be said to have a significant impact on gold prices in the long run at 10% significance level. In the models containing these indexes, CBOE volatility index affects gold prices inversely while WTI oil prices have no impact on gold prices. In the long term, the weakest findings in terms of coefficient significancies have been obtained for the model which includes S&P 500 Energy stock index returns. Furthermore, daily new cases in the world -contrary to the cases in U.S.- generally affect gold prices.

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Introduction

The novel coronavirus disease (officially called as COVID-19 by the World Health Organization [WHO]) that emerged in China has spread all over the world after a very short time. In Wuhan, Hubei Province; it was first reported on December 31, 2019; for the outside of China (Thailand), the first confirmed case was recorded on January 13, 2020 before long. On March 11, 2020; WHO announced the novel coronavirus as a global pandemic (WHO, 2020). Today, as of March 27, 2021; the numbers of total cases and deaths in the world have reached to 126,852.384 and 2,782.188 respectively. According to the Worldometer's website, as of March 27, the leading countries with respect to total cases are USA (30,854.944), Brazil (12,407.323) and India (11,908.910). The global effects of COVID-19 were severe, not restricted to the health crisis only; the pandemic evolved into a more profound economic and social crisis also. Soaring infection rates dragged the world into a shut down. Efforts to soften the outbreak -social distancing, workplace and school closures etc.- gave rise to human activities to be slowed to a standstill. In order to tackle with the negative impacts of the pandemic, governments of many countries dedicated massive amounts of money to their economic stimulus packages. As of April 2020, G20 economies have constitituted a remarkable portion of the global fiscal support - $8 trillion and on average, total revenue & spending measures for those economies have accounted for 4.5% of gross domestic product (GDP) implying a greater amount than those during the global financial crisis (GFC) (IMF, 2020). According to the G20 Fiscal Firepower Heat map which has been formed based on IMF methodolgy and revised through March 2021, fiscal spendings allocated to the COVID-19 relief (for 2020/2021 period fiscal stimulus) have been compared to those for GFC. This interactive map has implied the fact that China has spent 4.7% of GDP on COVID-19 relief while it is 16.5% of GDP for 2009 fiscal stimulus that is – showing that as the epicenter of the outbreak, China has spent less nowadays relative to 2009 fiscal stimulus with a difference of -11.8%. On the other hand; with the new stimulus plan in USA as the major country leading the pandemic, a huge amount of GDP (25.4%) has been allocated for the pandemic which represents a larger amount of 18.9% when compared to GFC fiscal stimulus (6.5%). 2020/2021 fiscal spendings that belong to other countries for COVID-19 relief are 16.2% (Australia), 14.6% (Canada), 11% (Germany), 8.3% (Brazil) – highlighting the severity and importance of the pandemic (Lipsky et al., 2021).

As associated with the pandemic, labor market analyses have revealed some crucial facts so that in the global sense, highest employment losses occurred in the Americas, and Europe & Central Asia where job retention schemes gave the opportunity of reducing working times - especially in Europe- had the lowest losses for the year 2020 and according to the gender, women experienced more employment losses (5%) when compared to men. Unprecedented global employment losses of 114 million jobs were recorded relative to 2019. Unemployment in the global scale escalated by 33 million in the year 2020, unemployment rate exhibited an increase of 1.1% points reaching to 6.5% eventually. Losses in global working hours in 2020 were approximately four times more than those experienced during the GFC in 2009 (ILO, 2021).

COVID-19 strain news have had profound and disproportionate effects on global economic activity and global financial markets. In the earlier times of the year, markets got stuck on obstacles. The Standard & Poor's 500 benchmark index recorded a fall by 8.4% in February and in March 2020, it plunged 12.5% as a result of lock-downs bringing the global economy to a standstill and then closed out the year 2000 with 16.3% gain. After its historical plunge, Wall Street made its way to bounce back with stocks ending the year at record highs (Los Angeles Times, 2020). Besides, according to the International Air Transport Association (IATA), air travel industry as a result of adopted strict air travel restrictions based on stringent

safety measures faced a major crisis with a total loss of $118 billion in the year 2020 and demand fell by 65.9% when compared to 2019. As parallel to the recovery news; according to the IMF Global Financial Stability Report (IMF, 2021) when the equity market performance for the base year 2020 (November 6) is evaluated, it can be said that COVID-19 vaccine announcements -starting with Pfizer & BioNTech at first and made earlier-than-expected- spearheaded to boost global economy by creating optimism in airline, hospitality and consumer services industries as investors turn their faces into those industries -that are being destroyed in the outbreak- in search of value.

Among the most traded commodities in the world, oil and gold have also been influenced by the outbreak. One conspicuous point about the oil market is that the price of West Texas Intermediate (WTI) crude oil futures contract for May delivery has recorded a collapse with an unprecedented negative level for the first time in history on April 2020 as demand dries up based on the COVID-19 restrictions.

Along with the effect of the pandemic in the initial times also, gold -considered with its safe haven characteristic for the times of economic turmoil- undoubtedly affected the main financial markets during the onset of the COVID-19 outbreak by leading to the exploding demand by investors: Gold futures price skyrocketed to reach a high level of $70 above the spot price. From the early times of 2020 until June, the amount of gold held by exchange traded funds (ETF) showed a drastic rise from 83 million oz to 103 million oz. On the other hand, the London Bullion Market Association (LBMA) recorded 6,573 transfers of gold amounting to 29.2 million oz ($46.4 billion)-experienced completely in March 2020 by indicating the greatest record of monthly transfers observed since 1996. It is remarkable to say that shipping and delivery options were seriously obstructed by the coronavirus mobility constraints, thus disrupting gold flow with increasing costs (LePan, 2020). By the late December 2020, the novel coronavirus strain fears with tough measures brought down the price of gold by as much as 1.3% on the face of strengthening dollar index as a risk aversion behaviour creating rattling markets apart from slumping forex and equity markets – while gold is expected to gain with its safe-haven potential (Sistla, 2020).

Comprehensive literature reviews have focused mostly either on the impacts of novel coronavirus on the gold volatility or the role of gold as associated with whether it represents a safe haven or not compared to Treasury bonds or cryptocurrencies -like Bitcoin, Ethereum etc.- (see, for example, Akhtaruzzaman et al., 2020; AlAli, 2020; Cheema et al., 2020; Dutta et al., 2020; Kumar, 2020; Mariana et al., 2021; Salisu et al., 2021).

Since it is crucial to examine the movements in gold and oil markets more closely in order to interpret the global economy and financial markets accurately, considering the importance of gold as a commodity in the pandemic; this study has aimed to focus on measuring the impact of novel coronavirus-related variables against various stock indexes (for Health Care, Technology, Medical Equipment, Financials, Industrials, Information Technology and Energy sectors) on logarithmic gold prices also by including WTI oil prices into the analysis.

Literature Review

With the emergence of the pandemic, studies on COVID-19 have recently gained momentum in a prominent manner, focusing on not only the impact on gold or oil prices, but also on stock markets and cryptomarkets or socioeconomic implications. A concise framework of the empirical studies that are associated with the novel COVID-19 pandemic which also cover gold as the main variable has been introduced in Table 1.

Table 1: An overview of the literature studies handling economic impacts of COVID-19

Author, Year	Time Span	Methodology	Key Findings
Corbet, Larkin and Lucey (2020)	March 11, 2019 to March 10, 2020 (hourly)	Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Dynamic Conditional Correlation (DCC)-GARCH	Chinese (Shanghai & Shenzhen) stock exchanges are interrelated significantly to WTI (West Texas Intermediate) oil, but insignificantly to gold and Bitcoin as hedging alternatives. Volatilities of Chinese financial markets have been influenced strongly, positively and significantly from COVID-19 environment.
Yousef and Shehadeh (2020)	January 3, 2012 to May 1, 2020	GARCH, GJR-GARCH	The number of daily new cases and cumulative global cases has been found to influence gold spot prices positively and coronavirus has created a significant positive effect on the volatility of daily gold returns.
Jana and Das (2020)	November 27, 2018 to February 14, 2020	GARCH(1,1) process, with an addition of crisis dummy to the return equation	Mainly, hedging and safe haven performances of Bitcoin and gold apart from Altcoins have been investigated. As a general result, gold is a strong hedge for all sectors covered in the study except Utilities sector which is significant at 10% level and a diversifier in the pre-crisis period; has performed superior than Bitcoin -by presenting better diversification opportunities- in terms of Chinese equity markets; however has been a weak safe haven during the crisis. Bitcoin has a weak hedge potential -for the entire sample- on average for the Energy, Consumer Discretionary and Telecommunication Services, acting as a diversifier for the other sectors, also being a weak safe haven at the onset of COVID-19 outbreak with an exception to Bloomberg commodity index.
Roy (2020)	January 30, 2019 to July 31, 2020	Vector Autoregression (VAR), Johansen Cointegration, Vector Error Correction Model, Granger Causality	The link between stock markets (Bombay Stock Exchange [BSE], National Stock Exchange [NSE]) and gold investment has been covered during COVID-19 outbreak in India. Among three macroeconomic variables, only for BSE and NSE, a bi-directional Granger causality has been observed. Coefficients of the dummy variable included into VAR equations to handle investor's preferences reveal that investors tend to prefer stock investments rather than the gold investment. Besides, no cointegrating relationship has been found among gold and stock markets.
Cheema, Faff and Szulczuk (2020)	For all assets covered in the study: December 31, 2003 to May 19, 2020 (for cryptocurrencies, sample period starts at September 17, 2014)	GJR-GARCH	The performance of traditional safe haven assets has been compared during both the 2008 Global Financial Crisis (GFC) and COVID-19 outbreak for the ten largest economies including S&P500 US index, SSE composite Index China, NIKKEI 225 Index Japan, MSCI Germany Index, FTSE100 Index UK, CAC 40 Index France, NIFTY 500 Index India, FTSE MIB Index Italy, MSCI Brazil Index and TSX composite Index Canada. As a result, gold has not provided an effective and safe protection of investors wealth in COVID-19 period, but being a safe haven in 2008 GFC. During the pandemic, Tether -as the largest stablecoin-, US Treasuries and the Swiss

			Franc have acted as strong safe havens when compared to Bitcoin being failed for all economies.
Salisu, Vo and Lawal (2020)	January 2016 to August 2020 (daily)	Asymmetric VARMA-GARCH model	The performance of gold as a safe haven or hedge against crude oil price risks stimulated through COVID-19 pandemic has been evaluated and gold has been found to serve as a significant safe haven against oil crisis. Additionally, optimal portfolio analyses have supported that gold shows an efficient performance with respect to hedging perspective.
Dutta, Das, Jana and Vo (2020)	December 2014 to March 2020	DCC-GARCH model (Time varying correlations)	Unconditional correlations between gold and WTI & Brent crude oil markets have shown that gold is uncorrelated or negatively correlated with US oil markets which is not the same case for Bitcoin that displays a positive correlation. A significant negative correlation of gold with WTI has revealed that gold acts as a safe haven asset while Bitcoin serves as a mere diversifier for global oil markets. Correlation coefficient - between oil and gold- which is higher in the coronavirus pandemic period indicates for gold to have a good hedging potential during the crisis.
Gharib, Mefteh-Wali and Jabeur (2021)	January 4, 2010 to May 4, 2020	Recursive rolling window, Time-varying Granger causality	The causal relationships between WTI light crude oil and gold spot prices have been analyzed and a bilateral contagion effect of bubbles has been detected in oil and gold markets during the coronavirus pandemic.
Mariana, Ekaputra and Husodo (2021)	July 1, 2019 to April 6, 2020	DCC-GARCH, corrected DCC	Bitcoin, Ethereum, gold, and S&P500 daily returns have displayed a more volatile structure during the COVID-19 outbreak. Two main cryptocurrencies -Bitcoin and Ethereum- have been found to exhibit short-term safe haven potentials for stocks. However, Ethereum has possibly a better safe-haven feature compared to Bitcoin based on the findings that for both before & after the outbreak, the dynamic correlations between Ethereum & gold are positive and Ethereum & gold are more positively correlated with one another rather than Bitcoin & gold during the outbreak.
Manohar and Raju (2021)	June 30, 2019 to June 30, 2020	Cross-Quantilogram (Han et al., 2016)	Hedge and safe haven perspectives of gold against extreme downturns in the stock market for energy sector indices have been analyzed during the pandemic. According to the findings; Saudi Arabia, Russia and Canada display a significant negative predictability in quantiles from energy sector indices to gold - supporting its safe haven potential during the outbreak. On the other hand, for all countries (USA, Saudi Arabia, UAE, Russia, Canada, China and India) covered in the study, a higher positive directional predictability has been detected implying the inability of gold in exhibiting its explicit hedge & safe haven potential prior to the outbreak.

Table 1 presents the results of 10 different studies. As can be seen, these studies frequently focus on GARCH modelling, causality and cointegration. The studies give insights on the relationships between gold and stock markets apart from oil markets under the COVID-19 environment (also considering daily new cases or cumulative global cases), also dealing with the safe haven and hedging performances of gold against COVID-19 outbreak and other crises. In the general sense; among the covered variables are Bitcoin (or other digital currencies), stock markets, WTI (or Brent) oil, Bloomberg commodity index in terms of examining the association with gold. Ultimately, based on the studies it is likely to say that hedge and safe-haven potentials of gold (and also Bitcoin) may show variability before and after the outbreak.

Data Set and Empirical Findings

In this study, it has been aimed to reveal the impacts of novel coronavirus disease (COVID-19) outbreak and macro-financial factors on daily gold prices in the global sense, especially presenting a comparative analysis with respect to distinct stock indexes by utilizing from Autoregressive Distributed Lag (ARDL) modelling approach. As the oil commodity, *West Texas Intermediate (WTI)* historical daily prices -which have been extracted from the Yahoo-Finance website- have been used in the research. In the analysis, the sample period (for the analysis with WTI) covers 10.03.2020–22.03.2021 period on a daily basis including a total of 255 observations. Time period has been chosen according to the data availability of all variables considered in the analysis when ICE LIBOR holiday calendar is also taken into account apart from the weekends. As the dependent variable of the analysis, the *prices of gold futures contracts* (ticker symbol GC) that are traded on Commodity Exchange (COMEX) -exhibiting the world's foremost benchmark futures contract for gold- have been used and data have been extracted from the Yahoo-Finance website covering the daily (historical) adjusted close prices (in dollars).

COVID-19-related variables used in the study are *daily new confirmed COVID-19 cases for United States* [USCASE] whose data have been extracted from *Our World in Data* website based on the COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University; *daily new confirmed cases in the world* [WCASE] (data source: *Worldometers*) and *COVID-19 Containment and Health Index* [COV_CH] for U.S. (data source: *Our World in Data*). COVID-19-Containment and Health Index is a crucial indicator which is defined according to *Our World in Data* as a composite measure established upon 13 policy response indicators including school closures, workplace closures, travel bans, testing policy, contact tracing, face covering and vaccine policy rescaled to a value from 0 to 100 (100 = strictest).

To gauge the nature of how stock markets show reactions to gold prices in the COVID-19 environment; *Dow Jones (DJ) Industrial Average* [DJ-IA], *S&P 500* [SP500], *DJ US Health Care* [DJ-HC], *DJ US Technology* [DJ-TECH], *DJ US Select Medical Equipment* [DJ-MDCEQP], *DJ US Financials* [DJ-FIN], *S&P 500 Health Care* [SP500-HC], *S&P 500 Industrials* [SP500-IN], *S&P 500 Information Technology* [SP500-IT] and *S&P 500 Energy* [SP500-EN] indexes have been covered. Data regarding those stock indexes have been obtained from the website of S&P Global in U.S. dollars excluding DJIA and S&P 500 indexes whose data have been taken from Yahoo-Finance website. Natural logarithmic forms of the series have been used in the research. Other used independent variables in the study are *Chicago Board Options Exchange (CBOE) Volatility Index* [VIX] as a macroeconomic risk indicator representing market expectations & changing market volatility and *EURO/USD exchange rate* [EURO/USD] that are obtained from the Yahoo-Finance website; *Bloomberg Commodity Index* [BCOM] (data source: https://www.marketwatch.com/) and *3-Month London Interbank Offered Rate (LIBOR) interest rates* [LIBOR] based on U.S. dollar (obtained from the website

of Federal Reserve Bank of St. Louis; main source: ICE Benchmark Administration Limited (IBA)).

In this research, in order to detect whether there is a cointegrating relationship among gold prices and other macro-financial variables also by incorporating COVID-19 related variables into the analysis against various sectoral stock indexes, it has been utilized from ARDL methodology pioneered by Pesaran et al. (2001) which also reveals short-run dynamics of the models encountered. In order to apply this methodology, all variables in the analysis should be either integrated of order 0 or 1 (I(0) or I(1)) but not I(2). Therefore, before implementing ARDL methodology, we have to be sure about there are no I(2) variables in the

Table 2: Unit root test results

Variables	Intercept		Intercept + Trend	
	Level	First Difference	Level	First Difference
LN GOLD	-1.988 (0)	-15.924	-1.716	-15.967
	[0.2917]	(0) [0.0000]***	(0) [0.7416]	(0) [0.0000]***
LN DJ-FIN	-1.204	-20.435	-5.558	
	(0) [0.6734]	(0) [0.0000]***	(0) [0.0000]***	
LN DJ-MDCEQP	-1.515	-20.114	-3.074	-20.106
	(1) [0.5244]	(0) [0.0000]***	(0) [0.1148]	(0) [0.0000]***
LN DJ-HC	-1.626	-21.538	-3.452	-21.503
	(0) [0.4676]	(0) [0.0000]***	(0) [0.0470]**	(0) [0.0000]***
LN DJ-TECH	-1.413	-23.711	-3.191	-23.707
	(1) [0.5759]	(0) [0.0000]***	(0) [0.0885]*	(0) [0.0000]***
LN DJ-IA	-21.914		-21.875	
	(0) [0.0000]***		(0) [0.0000]***	
LN SP500	-22.974		-22.927	
	(0) [0.0000]***		(0) [0.0000]***	
LN SP500-EN	-1.404	-18.525	-2.115	-18.515
	(0) [0.5803]	(0) [0.0000]***	(0) [0.5345]	(0) [0.0000]***
LN SP500-HC	-1.743	-11.513	-3.634	-11.527
	(0) [0.4084]	(1) [0.0000]***	(0) [0.0289]**	(1) [0.0000]***
LN SP500-IN	-0.825	-18.104	-5.387	
	(0) [0.8099]	(0) [0.0000]***	(0) [0.0001]***	
LN SP500-IT	-1.387	-24.195	-2.013	-24.183
	(1) [0.5887]	(0) [0.0000]***	(1) [0.5911]	(0) [0.0000]***
LN WTI	-0.809	-13.269	-2.558	-13.263
	(3) [0.8142]	(2) [0.0000]***	(3) [0.3003]	(2) [0.0000]***
LN BCOM	0.126	-15.417	-5.629	
	(0) [0.9671]	(0) [0.0000]***	(0) [0.0000]***	
LN EURO/USD	-0.929	-14.585	-2.354	-14.554
	(0) [0.7776]	(0) [0.0000]***	(0) [0.4030]	(0) [0.0000]***
LN LIBOR	-1.556	-13.255	-0.785	-13.306
	(0) [0.5036]	(0) [0.0000]***	(0) [0.9646]	(0) [0.0000]***
LN VIX	-2.281	-20.079	-3.497	-20.048
	(1) [0.1790]	(0) [0.0000]***	(0) [0.0418]**	(0) [0.0000]***

LN USCASE	-2.144	-5.691	-2.833	-5.332
	(6) [0.2278]	(5) [0.0000]***	(6) [0.1869]	(5) [0.0001]***
LN WCASE	-2.273	-5.479	-2.426	-5.419
	(6) [0.1815]	(5) [0.0000]***	(6) [0.3650]	(5) [0.0000]***
LN COV_CH	-13.373		-12.692	
	(0) [0.0000]***		(0) [0.0000]***	

Note: In Table 2; values in parantheses show the suitable lag lengths determined according to the Schwarz Information Criterion among max 15 lags. Brackets show probability values. ***, ** and * represent %1, %5 ve %10 significance levels respectively.

dataset. With this aim, Augmented Dickey-Fuller unit root test results have been outlined for all 19 variables in Table 2. Since the null hypothesis implies that there is a unit root in the series (the series is not stationary) while the alternative says the opposite; findings have supported that all variables covered in the study are either I(0) or I(1).

Table 3: ARDL Bounds test results

Model Specifications	F-Statistics		Conclusion
	Constant	Constant +Trend	
SP500	3.815747	4.497949	Cointegration
DJ-IA	4.226242	4.553520	Cointegration
DJ-HC	2.563848	3.221305	Inconclusive
DJ-TECH	2.254218	3.591033	Cointegration (C+T)
DJ-MDCEQP	2.493520	3.706737	Cointegration (C+T)
DJ-FIN	3.702750	5.070907	Cointegration
SP500-HC	2.567375	3.520474	Cointegration (C+T, 10%)
SP500-IN	6.129845	7.128884	Cointegration
SP500-IT	2.247828	3.597997	Cointegration (C+T)
SP500-EN	3.513131	4.816244	Cointegration

	Critical Values			
	10% Significance Level		5% Significance Level	
Model Specifications	Lower Bound I(0)	Upper Bound I(1)	Lower Bound I(0)	Upper Bound I(1)
Unrestricted Intercept	1.88	2.99	2.14	3.30
Intercept & Trend	2.16	3.24	2.43	3.56

Note. Analyses have been made based on AIC. Asymptotic critical value bounds for F-statistics have been obtained from Pesaran et al. (2001).

In Table 3, ARDL Bounds test results have been presented. According to the approach, if calculated F-statistics from the different model specifications are greater than the upper bound critical value (I(1)), it can be inferred that a cointegrating relationship exists among variables. But if calculated F-statistics takes place between lower and upper critical bounds, the result regarding the presence of a cointegrating relationship or absence becomes inconclusive. Bound test results have revealed that for all models excluding the model that includes DJ-HC sectoral stock index returns, a long-run relationship has been detected between gold prices and the other variables. For the sake of saving space and as parallel to the aim of the study which considers the sectoral stock indexes on the basis, applicational results have been presented for the stock indexes excluding S&P 500 and DJ-IA. In selecting the optimal number of lags, AIC has been used.

Table 4: ARDL model selection results including S&P500 (constant + trend)

MODELS	AICs
(1,3,1,4,4,1,0,4,4,0)	**-6.1309**
(1,3,2,4,4,1,0,4,4,0)	-6.1299
(1,3,1,4,4,2,0,4,4,0)	-6.1291
(3,1,1,4,0,1,0,0,2,0)	-6.1289
(3,1,1,4,0,1,0,1,2,0)	-6.1289

Table 5: ARDL model selection results including DJ-TECH (constant + trend)

MODELS	AICs
(1,1,0,2,4,0,0,1,2,0)	**-6.1337**
(1,1,0,2,4,0,0,1,2,1)	-6.1303
(4,1,0,2,4,0,0,1,2,0)	-6.1289
(3,1,0,2,4,0,0,1,2,0)	-6.1283
(1,1,1,2,4,0,0,1,2,0)	-6.1281

Table 6: DJ-TECH (C+T) selected model: ARDL(1, 1, 0, 2, 4, 0, 0, 1, 2, 0)

Variable	**Coefficients**	**Prob**	**Variable**	**Coefficients**	**Prob**
LNBCOM	0.864498	0.0003	C	0.712073	0.0000
LNCOV_CH	-0.390487	0.0096	@TREND	-0.000492	0.0000
LNDJ_TECH	0.167779	0.2409	D(LNBCOM)	0.665924	0.0000
LNEXCH	0.118839	0.7298	D(LNDJ_TECH)	0.117023	0.0093
			D(LNDJ_TECH(-1))	-0.095805	0.0038
LNLIBOR	-0.024259	0.4078			
LNUSCASE	0.001921	0.9207	D(LNEXCH)	0.198582	0.1792
LNVIX	-0.044537	0.1711	D(LNEXCH(-1))	-0.203943	0.1563
LNWCASE	0.110194	0.0005	D(LNEXCH(-2))	-0.310264	0.0320
LNWTI	-0.083762	0.0042	D(LNEXCH(-3))	-0.301991	0.0360
			D(LNVIX)	0.023845	0.0273
Breusch-Godfrey LM: 0.8425			D(LNWCASE)	0.007443	0.1249
Breusch-Pagan-Godfrey: 0.9204			D(LNWCASE(-1))	-0.012647	0.0137
ARCH: 0.6132			CointEq(-1)*	-0.207818	0.0000
R-squared: 0.970603					
Adjusted R-squared: 0.967907					
Model Significancy F-statistic: 360.0409					
Model Significancy Prob (F-statistic): 0.000000					
Ramsey-Reset F-statistic F(1, 228) = 0.186294					

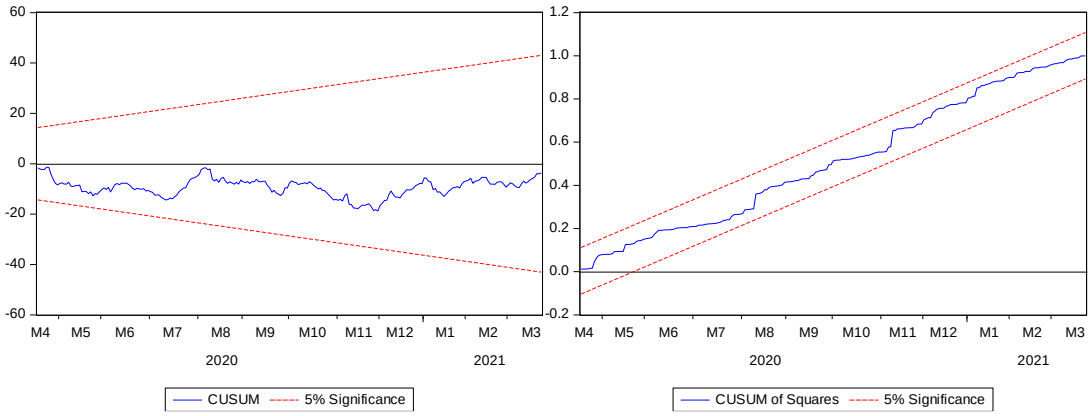

Figure 1: CUSUM stability tests for DJ-TECH (C+T) ARDL(1, 1, 0, 2, 4, 0, 0, 1, 2, 0) model

The model in Table 6 shows the ARDL model findings including Dow-Jones Technology sector index. According to the results, gold prices have not been influenced by DJ-TECH index price returns in the long-run. Variables that are related to COVID-19 pandemic -excluding daily new cases in US- have a significant impact on COMEX gold prices. Thus, in the ARDL model where TECH sectoral index is taken into account, daily new cases in the world are seen to increase the gold prices. As an indicator of COVID-19 restrictions, a 100% increase in Containment and Health Index will give rise to a decrease of gold prices approximately by 39%. In addition, WTI crude oil prices have a negative impact on gold prices in the LR. Model has satisfied all required stability and diagnostic checkings. Thus, it can be said that there is no autocorrelation and heteroscedasticity problem in the regression model including DJ-TECH. Considering also the trend effect in the model, short run findings have revealed the implications contrary to the long-run: In the short run, DJ-TECH index returns have a significant impact on gold prices. The effect of VIX on gold is significant in the short run when compared to long-run. BCOM index has affected gold prices both in the long run and short run. In the ARDL(1, 1, 0, 2, 4, 0, 0, 1, 2, 0) model with unrestricted constant and unrestricted trend, the impact of Bloomberg commodity index on gold prices is more remarkable (0.665924) when compared to other variables. On the other hand, error correction term represented by CointEq(-1)* is both negative and significant. The stability of the model has been checked by CUSUM test. Since CUSUM line takes place between 5% significance lines, our model has also met the stability condition.

Table 7: DJ-MDCEQP (C+T) selected model: ARDL(4, 1, 1, 2, 4, 0, 0, 1, 2, 0)

Variable	Coefficients	Prob	Variable	Coefficients	Prob
LNBCOM	0.786516	0.0010	C	0.712073	0.0000
LNCOV_CH	-0.427740	0.0028	@TREND	-0.000492	0.0000
LNDJ_MDCEQP	0.120918	0.4168	D(LNGOLD(-1))	-0.035392	0.5464
LNEXCH	0.366118	0.2604	D(LNGOLD(-2))	0.128132	0.0266
LNLIBOR	-0.027621	0.2856	D(LNGOLD(-3))	0.079965	0.1439
LNUSCASE	0.004482	0.8037	D(LNBCOM)	0.700710	0.0000
LNVIX	-0.051644	0.0944	D(LNCOV_CH)	-0.146949	0.0000
LNWCASE	0.097179	0.0015	D(LNDJ_MDCEQP)	0.012795	0.8093
LNWTI	-0.068396	0.0338	D(LNDJ_MDCEQP(-1))	-0.132816	0.0016
			D(LNEXCH)	0.318172	0.0395
Breusch-Godfrey LM: 0.1398			D(LNEXCH(-1))	-0.305278	0.0489
Breusch-Pagan-Godfrey: 0.9336			D(LNEXCH(-2))	-0.406102	0.0092

ARCH: 0.8632	D(LNEXCH(-3))	-0.349224	0.0200
R-squared: 0.970586	D(LNVIX)	0.009074	0.3873
Adjusted R-squared: 0.967318	D(LNWCASE)	0.002795	0.5627
Model Significancy F-statistic: 296.9769	D(LNWCASE(-1))	-0.015204	0.0038
Model Significancy Prob (F-statistic): 0.000000	CointEq(-1)*	-0.229498	0.0000
Ramsey-Reset F-statistic F(1, 224) = 0.000000			

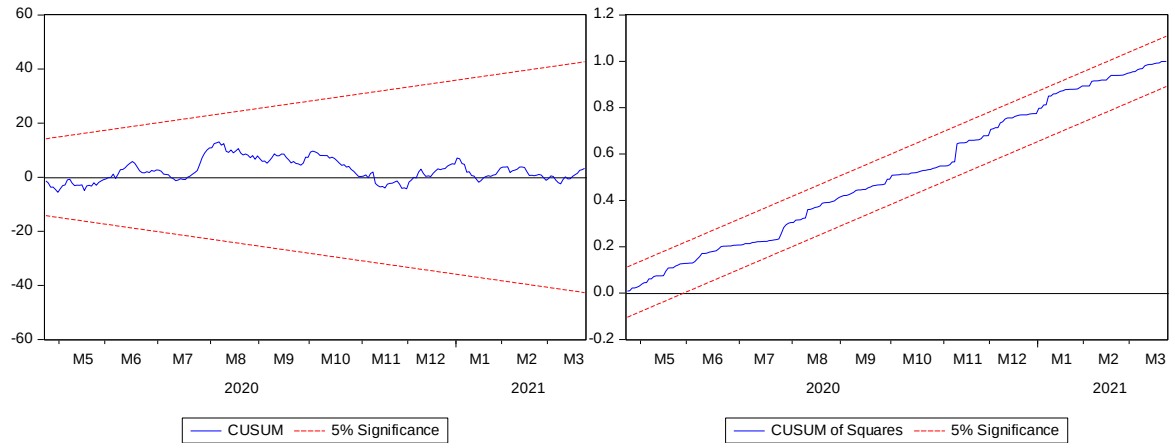

Figure 2: CUSUM stability tests for DJ-MDCEQP (C+T) ARDL(4, 1, 1, 2, 4, 0, 0, 1, 2, 0) model

According to ARDL(4, 1, 1, 2, 4, 0, 0, 1, 2, 0) model results, as in the case of DJ-Technology sector, Dow Jones – Medical Equipment sectoral index has also not affected gold prices in the long-run. As consistent with the previous results, gold prices have been affected the most by the BCOM index in a positive and significant manner for both long run and short run. Daily new cases in the world rather than the cases in U.S. are dominant on gold prices in the long-run. Findings have revealed that error correction mechanism performs in a good way with its negative and significant error correction term (-0.229448).

Table 8: DJ-FIN (C) selected model: ARDL(2, 3, 4, 1, 3, 0, 0, 0, 2, 3)

Variable	Coefficients	Prob	Variable	Coefficients	Prob
LNBCOM	-0.034959	0.8686	C	1.619319	0.0000
LNCOV_CH	-0.180768	0.4542	D(LNGOLD(-1))	-0.113027	0.0677
LNDJ_FIN	-0.596159	0.0008	D(LNBCOM)	0.731458	0.0000
LNEXCH	0.678465	0.2107	D(LNBCOM(-1))	0.059872	0.5338
LNLIBOR	0.036571	0.3105	D(LNBCOM(-2))	0.279123	0.0021
LNUSCASE	-0.031750	0.2901	D(LNCOV_CH)	-0.069268	0.0163
LNVIX	-0.104075	0.0212	D(LNCOV_CH(-1))	0.059043	0.0274
LNWCASE	0.090678	0.0734	D(LNCOV_CH(-2))	-0.041280	0.1273
LNWTI	0.039746	0.4419	D(LNCOV_CH(-3))	-0.041231	0.1325
			D(LNDJ_FIN)	-0.146995	0.0001
Breusch-Godfrey LM: 0.3934			D(LNEXCH)	0.462931	0.0043
Breusch-Pagan-Godfrey: 0.0052			D(LNEXCH(-1))	-0.152339	0.3129
ARCH: 0.9777			D(LNEXCH(-2))	-0.299379	0.0462
R-squared: 0.971044			D(LNWCASE)	0.001266	0.7936

Adjusted R-squared: 0.967538	D(LNWCASE(-1))	-0.008731	0.0813
Model Significancy F-statistic: 276.9759	D(LNWTI)	-0.023756	0.0051
Model Significancy Prob (F-statistic): 0.000000	D(LNWTI(-1))	-0.024893	0.0111
Ramsey-Reset F-statistic F(1, 222) = 1.800856	D(LNWTI(-2))	-0.019301	0.0262
	CointEq(-1)*	-0.139978	0.0000

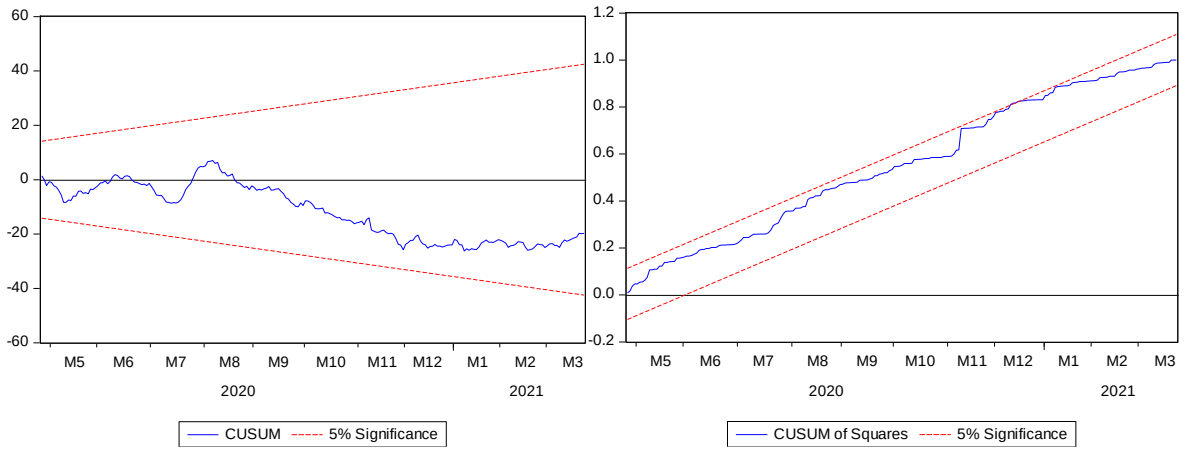

Figure 3: CUSUM stability tests for DJ-FIN (C) ARDL(2, 3, 4, 1, 3, 0, 0, 0, 2, 3) model

Empirical findings of the ARDL (2, 3, 4, 1, 3, 0, 0, 0, 2, 3) model have shown that Dow-Jones Financials sector index returns have influenced gold returns negatively (-0.596159) in the long-run, also for short-run. Additionally, exchange rate and LIBOR interest rates do not make a contribution to gold prices in the long-run. Error correction mechanism has performed well with the adjustment coefficient of -0.139978. Once again, when compared to the US daily new cases, the effect of world cases on gold prices is more distinct. Although Breusch-Pagan-Godfrey (BPG) test statistic which is significant at 5% significance level indicates the heteroscedasticity problem, there is no autoregressive conditional heteroscedasticity problem encountered in this model. White covariance matrix has been used in the analysis based on the existence of the possible heteroscedasticity problem determined according to the BPG test.

Table 9: SP500-HC (C+T) selected model: ARDL(3, 1, 1, 4, 0, 2, 0, 1, 2, 0)

Variable	Coefficients	Prob	Variable	Coefficients	Prob
LNBCOM	0.899075	0.0002	C	0.913555	0.0000
LNCOV_CH	-0.449727	0.0064	@TREND	-0.000467	0.0000
LNSP_HC	0.055338	0.7531	D(LNGOLD(-1))	-0.060047	0.2997
LNEXCH	0.262926	0.4768	D(LNGOLD(-2))	0.092212	0.1007
LNLIBOR	-0.030492	0.2708	D(LNBCOM)	0.714413	0.0000
LNUSCASE	0.005308	0.7931	D(LNCOV_CH)	-0.143382	0.0000
LNVIX	-0.052131	0.1578	D(LNEXCH)	0.327822	0.0370
LNWCASE	0.107103	0.0019	D(LNEXCH(-1))	-0.218142	0.1596
LNWTI	-0.077100	0.0170	D(LNEXCH(-2))	-0.342917	0.0233
			D(LNEXCH(-3))	-0.301060	0.0452
Breusch-Godfrey LM: 0.1672			D(LNSP-HC)	-0.014736	0.8032
Breusch-Pagan-Godfrey: 0.8685			D(LNSP-HC(-1))	-0.119983	0.0083
ARCH: 0.8914			D(LNVIX)	0.007764	0.4607

R-squared: 0.970085	D(LNWCASE)	0.003696	0.4455
Adjusted R-squared: 0.966909	D(LNWCASE(-1))	-0.014391	0.0062
Model Significancy F-statistic: 305.3682	CointEq(-1)*	-0.205904	0.0000
Model Significancy Prob (F-statistic): 0.000000			
Ramsey-Reset F-statistic F(1, 225) = 0.015044			

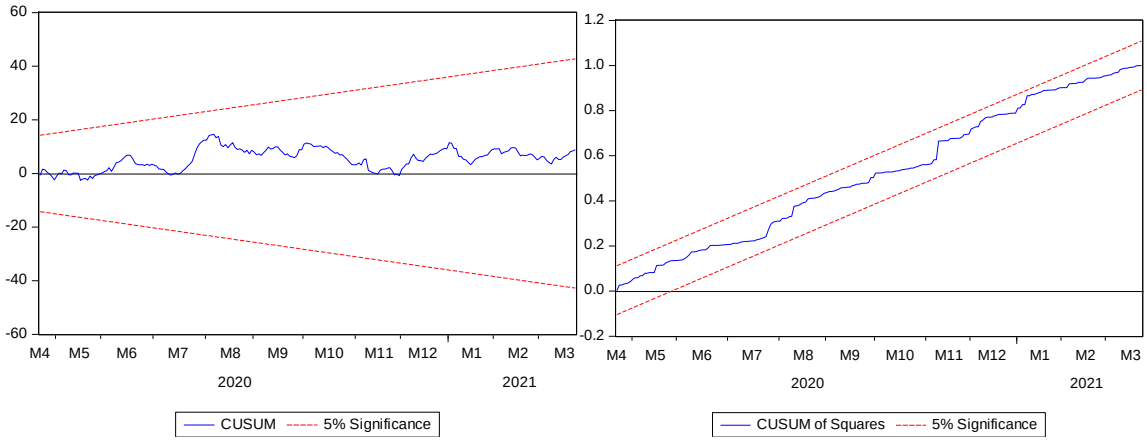

Figure 4: CUSUM stability tests for SP500-HC (C+T) ARDL(3, 1, 1, 4, 0, 2, 0, 1, 2, 0) model

ARDL(3, 1, 1, 4, 0, 2, 0, 1, 2, 0) model presents the similar results regarding the COVID-19 related variables. BCOM was the variable which has the greatest impact on gold prices in the short run and affected gold prices in the same direction (positively) in the short run (0.714413) as in the long run (0.899075). In neither long nor the short term, the S&P 500 health care sector has no significant effect on gold prices. Furthermore, one more time the model confirms that LIBOR interest rates and euro / dollar exchange rate do not have an impact on gold prices in the long-run.

Table 10: SP500-IN (C) selected model: ARDL(2, 3, 2, 0, 1, 0, 0, 4, 4, 3)

Variable	Coefficients	Prob	Variable	Coefficients	Prob
LNBCOM	0.126116	0.3635	C	2.499688	0.0000
LNCOV_CH	-0.364972	0.0380	D(LNGOLD(-1))	-0.110570	0.0664
LNEXCH	0.478541	0.2150	D(LNBCOM)	0.741753	0.0000
LNSP-IN	-0.836683	0.0000	D(LNBCOM(-1))	0.139830	0.1553
LNUSCASE	-0.068506	0.0022	D(LNBCOM(-2))	0.341537	0.0002
LNVIX	-0.183209	0.0000	D(LNCOV_CH)	-0.104014	0.0003
LNWCASE	0.215846	0.0000	D(LNCOV_CH(-1))	0.069077	0.0069
LNWTI	-0.014707	0.6562	D(LNEXCH)	0.512898	0.0016
LNLIBOR	0.067424	0.0116	D(LNVIX)	-0.013055	0.1563
			D(LNVIX(-1))	0.016214	0.0902
			D(LNVIX(-2))	0.021536	0.0206
			D(LNVIX(-3))	0.018072	0.0333
			D(LNWCASE)	0.010110	0.0489
Breusch-Godfrey LM: 0.8417			D(LNWCASE(-1))	-0.026340	0.0001
Breusch-Pagan-Godfrey: 0.0101			D(LNWCASE(-2))	-0.009839	0.0930
ARCH: 0.9572			D(LNWCASE(-3))	-0.010426	0.0552
R-squared: 0.972459			D(LNWTI)	-0.023738	0.0040
Adjusted R-squared: 0.968986			D(LNWTI(-1))	-0.018343	0.0512

Model Significancy F-statistic: 279.9561	D(LNWTI(-2))	-0.016668	0.0449
Model Significancy Prob (F-statistic): 0.000000	CointEq(-1)*	-0.197779	0.0000
Ramsey-Reset F-statistic F(1, 221) = 0.458339			

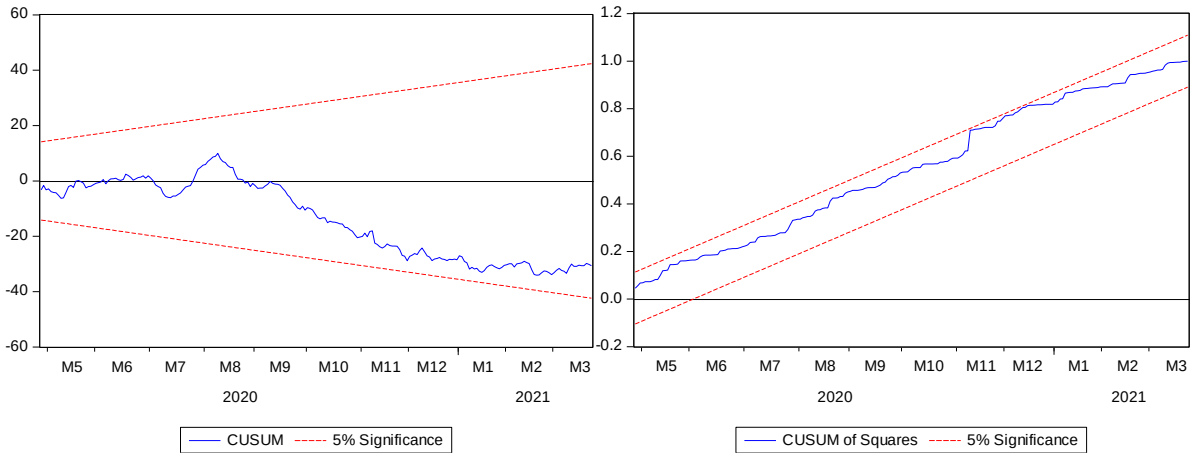

Figure 5: CUSUM stability tests for SP500-IN (C) ARDL(2, 3, 2, 0, 1, 0, 0, 4, 4, 3) model

As reported in Table 10, ARDL(2, 3, 2, 0, 1, 0, 0, 4, 4, 3) model results indicate a significant Breusch-Pagan-Godfrey statistic (0.0101), but an insignificant ARCH statistic (0.9572) implying that there is no ARCH effect in the model (White covariance matrix has been used in the analysis depending on the presence of heteroscedasticity problem detected according to the BPG test). On the other hand, as different from the previous results, the most effective significant variables on gold prices are S&P 500- Industrial sector index (-0.837) and Covid-19 Containment and Health Index (-0.365) respectively. According to the model findings, while an increase in the daily new cases in the world also increases the gold prices; US new daily cases have an inverse effect on gold. It is also remarkable to say that while euro/dollar exchange rate, BCOM and WTI are not important for gold prices against S&P 500 industrial sector returns in the long run; LIBOR interest rates have shown a positive impact on gold (0.067424).

Table 11: SP500-IT (C+T) selected model: ARDL(1, 1, 0, 2, 4, 0, 0, 1, 2, 0)

Variable	Coefficients	Prob	Variable	Coefficients	Prob
LNBCOM	0.865135	0.0003	C	0.715954	0.0000
LNCOV_CH	-0.388795	0.0094	@TREND	-0.000493	0.0000
LNEXCH	0.087603	0.8017	D(LNBCOM)	0.674713	0.0000
LNLIBOR	-0.025777	0.3567	D(LNEXCH)	0.204846	0.1706
LNSP500-IT	0.178883	0.2341	D(LNEXCH(-1))	-0.192258	0.1846
LNUSCASE	0.003414	0.8581	D(LNEXCH(-2))	-0.309575	0.0333
LNVIX	-0.041889	0.2039	D(LNEXCH(-3))	-0.297996	0.0398
LNWCASE	0.107975	0.0006	D(LNSP500-IT)	0.102678	0.0249
LNWTI	-0.083176	0.0042	D(LNSP500-IT(-1))	-0.093815	0.0049
Breusch-Godfrey LM: 0.7983			D(LNVIX)	0.021699	0.0449
Breusch-Pagan-Godfrey: 0.9144			D(LNWCASE)	0.007354	0.1329
ARCH: 0.6597			D(LNWCASE(-1))	-0.013127	0.0111
R-squared: 0.970324			CointEq(-1)*	-0.210385	0.0000
Adjusted R-squared: 0.967603					
Model Significancy F-statistic: 356.5597					
Model Significancy Prob (F-statistic): 0.000000					

Ramsey-Reset F-statistic F(1, 228) = 0.138378	

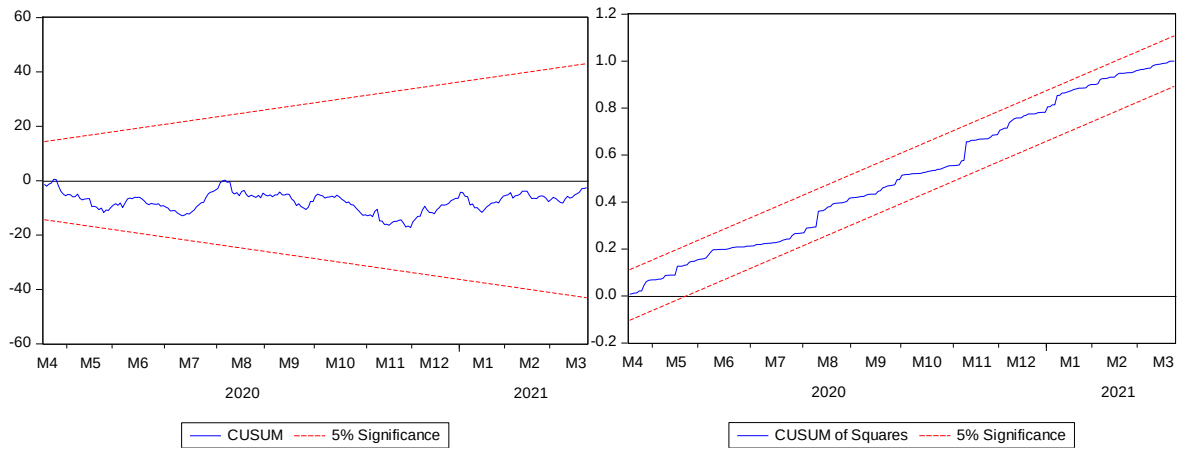

Figure 6: CUSUM stability tests for SP500-IT (C+T) ARDL(1, 1, 0, 2, 4, 0, 0, 1, 2, 0) model

S&P 500 – Information Technology index returns do not have a significant impact on gold prices in the long run while they influence gold prices in the short-run significantly. COVID-19 related variables have affected gold prices as similar to the general results for other models. The greatest impact on gold in the long-run has come from the BCOM index.

Table 12: SP500-EN (C) selected model: ARDL(2, 3, 4, 2, 4, 0, 0, 0, 0, 3)

Variable	Coefficients	Prob	Variable	Coefficients	Prob
LNBCOM	-0.280197	0.1828	C	1.260822	0.0000
LNCOV_CH	-0.429249	0.2027	D(LNGOLD(-1))	-0.129133	0.0392
LNEXCH	0.690350	0.3032	D(LNBCOM)	0.817577	0.0000
LNLIBOR	0.024316	0.5650	D(LNBCOM(-1))	0.093305	0.3764
LNSP500-EN	-0.174630	0.0589	D(LNBCOM(-2))	0.243723	0.0055
LNUSCASE	0.032692	0.3723	D(LNCOV_CH)	-0.087279	0.0030
LNVIX	-0.106442	0.0590	D(LNCOV_CH(-1))	0.041718	0.1139
LNWCASE	-0.029005	0.6043	D(LNCOV_CH(-2))	-0.066044	0.0173
LNWTI	0.055527	0.4071	D(LNCOV_CH(-3))	-0.062303	0.0240
			D(LNEXCH)	0.316710	0.0427
			D(LNEXCH(-1))	-0.263780	0.0720
			D(LNEXCH(-2))	-0.358773	0.0141
Breusch-Godfrey LM: 0.3575			D(LNEXCH(-3))	-0.254169	0.0885
Breusch-Pagan-Godfrey: 0.0003			D(LNSP500-EN)	-0.121232	0.0000
ARCH: 0.8726			D(LNSP500-EN(-1))	-0.047657	0.0515
R-squared: 0.972132			D(LNWTI)	-0.021382	0.0114
Adjusted R-squared: 0.968758			D(LNWTI(-1))	-0.023671	0.0142
Model Significancy F-statistic: 288.1099			D(LNWTI(-2))	-0.020286	0.0173
Model Significancy Prob (F-statistic): 0.000000			CointEq(-1)*	-0.109062	0.0000
Ramsey-Reset F-statistic F(1, 222) = 1.249711					

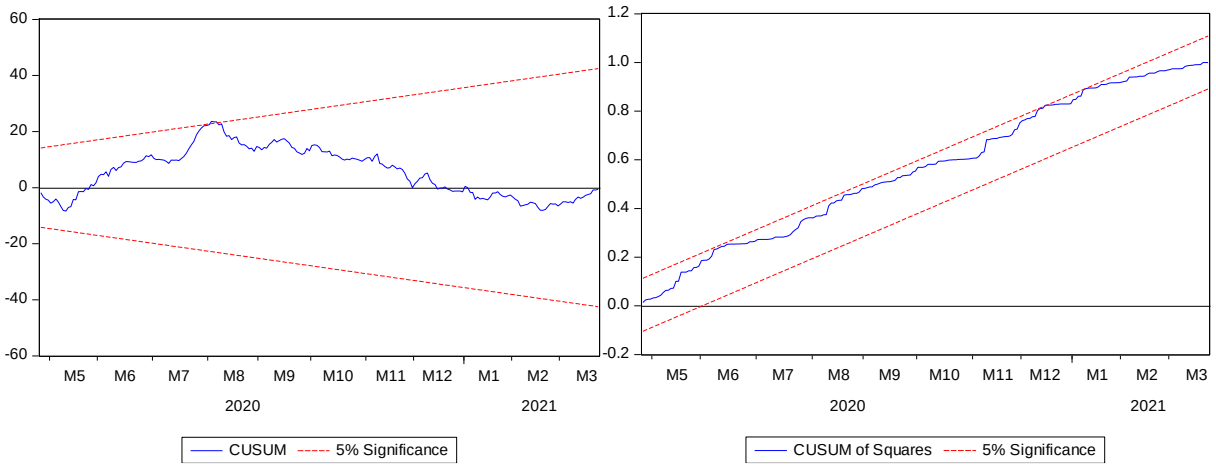

Figure 7: CUSUM stability tests for SP500-EN (C) ARDL(2, 3, 4, 2, 4, 0, 0, 0, 0, 3) model

In ARDL(2, 3, 4, 2, 4, 0, 0, 0, 0, 3) model, where S&P 500 energy stock index returns are taken into account, COVID-19 related variables have no impact on gold prices this time. Significant variables in the model are only VIX and S&P 500-EN returns in the long-run for 10% significance level. As in all ARDL models regarding the study, error correction mechanism has performed well implied by the negative and significant adjustment coefficient (-0.109062).

The best model including DJ-HC (with constant) has been selected as ARDL(2, 1, 1, 2, 4, 0, 0, 1, 0, 1) based on the Bounds testing approach. However, whether there is a cointegrating relationship between gold prices and other variables or not is inconclusive. Although not presented here for the sake of saving space, for that model variables are in interaction for short-run. DJ-HC index returns have been found not to have a significant impact on gold prices in the short-run. Besides, COVID-19 measures (implied by the Containment & Health Index) can be said to influence gold prices in a negative direction.

Conclusion

COVID-19 pandemic has influenced not only health sector but also financial markets. Considering its importance with respect to economic consequences, in this study it has been aimed to investigate the impacts of COVID-19 related variables and macro-financial indicators on gold prices using ARDL methodolgy. ARDL models have been chosen in a way to give the minimum value of AIC in the analyses.

Long-run and short-run findings of the analyses are mixed. In the ARDL(1, 1, 0, 2, 4, 0, 0, 1, 2, 0) model, gold prices are affected by DJ-TECH in the short run rather than in the long-run. The variable affecting gold prices the most and significantly in the short-run has been BCOM index. This model with DJ-TECH has shown that as the novel coronavirus restrictions and measures increase (implied by the Containment & Health Index), gold prices experienced a drastic fall in the long-run (implied by the coefficient -0.390). In addition, gold prices have been influenced by the world new daily cases in the same direction more than the cases observed in U.S in the short run.

ARDL(2, 3, 2, 0, 1, 0, 0, 4, 4, 3) model results indicate that the most effective significant variables on gold prices have been found as S&P 500-industrial sector index and Covid-19 Containment and Health Index respectively. Besides; euro/dollar exchange rate, BCOM and WTI have been determined not to be important for gold prices against S&P 500 industrial sector returns in the long run.

In ARDL(2, 3, 4, 2, 4, 0, 0, 0, 0, 3) model, where S&P 500 energy stock index returns are taken into account, COVID-19 related variables have no impact on gold prices this time. Significant variables in the model have been detected to be only VIX and S&P 500-EN returns in the long-run when 10% significance level is considered.

According to the ARDL(2, 1, 1, 2, 4, 0, 0, 1, 0, 1) model results based on the Bounds testing approach, it can be stated that whether there exists a cointegrating relationship between gold prices and other variables or not is inconclusive. However, short-run interactions have implied that DJ-HC index returns do not have a significant impact on gold prices in the short-run. Additionally, COVID-19 measures (implied by the Containment & Health Index) have an interaction with gold prices in a negative way.

Excluding the model which includes DJ-HC sector, a cointegrating (long-run) relationship has been found between gold prices and other independent variables considered. SP-HC does not show a significant impact at neither long-run nor short-run. S&P 500 – Industy index returns have influenced gold prices negatively (-0.837) and significantly in the long-run. If WTI variable is found to be significant in the model, an increase in WTI crude oil prices conforms to a decrease in gold prices in the general sense. S&P500-IT sector has a significant impact on gold prices in short run, but insignificant impact in the long-run. VIX has mixed results on gold prices. In the long run, Euro/dollar exchange rate and LIBOR interest rates do not have a significant impact on gold prices in the general sense.

DJ-FIN sectoral index returns have affected gold prices negatively in both long and short run. Besides, DJ-TECH and DJ-MDCEQP (for one-lagged period) sectoral index returns are more important in accounting for gold prices only in the short run. The only model where LIBOR has an impact on gold prices in the long run is ARDL(2, 3, 2, 0, 1, 0, 0, 4, 4, 3) model.

When all models are evaluated generally, it can be said that the remarkable impact on gold prices in the long-run has come from BCOM index and subsequently another major contribution belongs to the COVID-19 Containment and Health Index variable which affects gold prices in the negative direction.

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