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## COVID-19: A Game-changer to Equity Markets?

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### Abstract

This article applies the effective transfer entropy methodology to quantify the information flow between equities in major global equity markets in Australia, Brazil, Canada, China, Germany, Iran, Japan, Qatar, Saudi Arabia, South Africa, South Korea, United Kingdom, and the United States—a pool of 2200 companies is included. To account for COVID-19 impacts, the period of the study was extended over two years. The results show changes to the information flow pattern after COVID-19, with the largest changes being encountered in Australia, Brazil, Canada, Japan, and the United States for their largest market participants (by market capitalization). In comparison, the Asian markets' information flow patterns show less noticeable changes following COVID-19. On a sector level, most of the markets studied have seen substantial changes in the functionality of their sectors—in terms of being a transmitter or receiver of information—after COVID-19's appearance. The fraction of sectors with a complete change in their influencing role since COVID-19 has been over 70% in Australia, Canada, South Africa, and the United States. The financial services sector has retained its role as being the most influential sector in 6 out of 13 markets considered after COVID-19. For most of the markets, the basic materials, communications, energy, and utilities sectors have retained an intermediate position in the information flow diagram after COVID-19. The German market has been the only market, in which the main information transmitter and receiver sectors have remained unchanged since COVID-19. The results suggest drastic moves in major global equity markets, which have been concurrent with the virus outbreak.

**Keywords:** COVID-19, Equity Markets; Effective Transfer Entropy.

## 1. Introduction

Many of us think of the world in two time periods – before and after the COVID-19 pandemic. This thinking might have been initiated because of the complex elements of the COVID-19 issue involving both known and unknown. Apart from its medical complexities, the COVID-19 crisis has left us with ambiguities about its other impact dimensions as well. Thus far, studies have found that this global disruption has influenced several affairs with respect to the psychological well-being of people [1], the environment [2], education [3], and geopolitics [4], to name a few.

In terms of finance and capital markets, researches have been performed to study the link between the COVID-19 pandemic and financial aspects in the scope of banking [5-9], cryptocurrency [10-16], exchange rates [17, 18], financial

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system [19], insurance [20], interest rates [21] and equity markets [22–46]. In the case of equity markets, the effects of the COVID-19 outbreak have been investigated on the return [27–28, 41–43, 46] and volatility [26, 32, 42–44] of the market in developed [22, 29] and developing [39, 45] economies. The bulk of these studies have found marked differences in the market behavior before and after the pandemic announcement – an increase in volatility and a decrease in returns after the pandemic outbreak. Nevertheless, this market reaction is found to vary across countries [32, 44]. For example, Harjoto et al. [22] found the stock returns, volatility, and trading volume of equity markets in developed countries to be affected by the news about COVID-19 mortality rates, while in the case of developing economies, both mortality rates and the number of infections were found to be influential. Grouping the COVID-19 deaths and cases into an anxiety index, Yu et al. [27] found a dynamic correlation between stock returns and the anxiety index, which has been decreasing since the introduction of the mRNA-based vaccine. Fry-McKibbin et al. [29] suggest the global equity markets are exposed to pandemic risk factors and find evidence of contagion across multiple channels from the U.S. to G20 equity markets. Bissoondoyal-Bheenick et al. [42] conclude that the stock return and volatility connectedness in G20 markets will increase as the COVID-19 crisis escalates. Benlagha and El Omari [31] report that the linkage between the major global equity markets (China, Germany, Japan, U.K., and U.S.) has increased after the COVID-19 outbreak. In addition, the risk spillovers from equity markets in the American and European regions are found to have increased following the COVID-19 epidemic [33], while Asian markets have been more resilient to the situation [34]—showing a decrease in the risk contagion effects [33]. In this respect, the negative effects of the COVID-19 pandemic on Asian equity markets are reported to be less severe compared to other regions of the world. For example, Salman and Ali [45] studied the equity markets in several Asian countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) and found a negative short-term impact on these markets from the COVID-19 crisis. Some studies [30] have also pointed out the weak integration of some Asian markets (China and Saudi Arabia) into the global market reaction that abounds following the COVID-19 appearance.

To further elucidate the equity market response to the COVID-19 issue, some empirical studies have focused on the market performance through its constituents, on a sector level [37, 38, 40]. For example, He et al. [38] reported the manufacturing, information technology, education, and health-care industries in China as being the most resilient sectors within the pandemic timeline, while the transportation, mining, electricity, and environmental industries are found to be the most vulnerable to the COVID-19 crisis in the Chinese market. Alam et al. [40] inspected the sectoral performance of the Australian equity market in the immediate days following the COVID-19 announcement and found good performance for the telecommunications, pharmaceuticals, and healthcare sectors in this period. Buszko et al. [37] analyzed the sector constituents of the Warsaw Stock Exchange during the COVID-19 pandemic and found the construction, information technology, game developers, biotechnology, telecoms, and new technology sectors to exhibit positive relative changes in their average prices in the medium-term period after the crisis began. While some other sectors—automobiles, banking, chemicals, clothes, energy, food, mining, oil & gas, pharmaceuticals, and real estate—were found unprofitable within the same timeline in that market.

The mentioned literature should signal the radical changes undergoing the global equity markets in the aftermath of COVID-19 outbreak. Given the new circumstances, acquiring knowledge of the exact interaction between market constituents should be of utmost importance. Nevertheless, the methods adopted in some of the previous investigations seem to be barely adequate to provide us with a detailed picture of the market activity. For instance, the Granger causality method is unable to measure the nonlinear relations between financial time series and cannot ascertain the direction of information flow between the two sets [47]. In this respect, the methodology of transfer entropy [48] can address both deficiencies – with the added benefits of being invariant to linear transformation and not being restricted to linear dynamics. The output of this new proxy – information flow between market constituents – can be used to determine the information-dominant component(s) in a market. This latter data can be directly used by stakeholders to react appropriately to information transfer dynamics by adjusting their market status based on the interaction hierarchy among the components in their portfolio. In addition, the acquisition of a true map of information flow among equities would enable us to reliably determine the performance of market sectors in a given period by accounting for the net information flow for the companies belonging to the given sectors. Although the concept of (effective) entropy transfer has been expensively applied in financial markets [47, 49–55], its application in analyzing the market status after COVID-19 outbreak seems to be un-attempted.

The present article contributes to the existing literature in this field in different ways. The article reports on the first application of the transfer entropy methodology to analyze the sector performance of several equity markets in the aftermath of COVID-19. In this respect, the article has reached a great milestone of quantifying the information flow between market constituents—comprised of 2200 companies—active in major equity markets worldwide. The number and distribution of companies/markets considered should further weight our results, to be a detailed map of the current market status within the COVID-19 crisis, in a global sense. The results presented and the methods applied herein are the first to be reported for some Asian markets, such as the Tehran Stock Exchange, for which previous studies are minimal.

## 2. Research Methodology

In this section, we outline the method of transfer entropy which was used as the main processing stream in the present work. Proposed by Schreiber [48], the transfer entropy methodology quantifies the asymmetric dynamics of two processes, using the conditional block entropy [55]. In this context, the entropy is defined as a proxy to measure the uncertainty level inherent in optimally encoding the independent draws of a discrete random variable. The formulation of transfer entropy is then based on the premise of Shannon entropy [47]. Assuming  $X$  as being a discrete random variable, with probability distribution function  $p(x_t)$ , the Shannon entropy,  $H_X$ , is defined as:

$$H_X = -\sum p(x_t) \log_2(p(x_t)) \quad (1)$$

If the random variable  $X$  represents the event space of a time series, the sequence of its state outcomes until time  $t$ , with  $k$  back steps in time, becomes:

$$x_t^{(k)} = x_t, x_{t-1}, x_{t-2}, \dots, x_{t-k+1} \quad (2)$$

If we denote the probability of observing the variable in state  $x$  at time  $t+1$  as  $p(x_{t+1}|x_t^{(k)}) = p(x_{t+1}|x_t, \dots, x_{t-k+1})$  then the average number of bits needed to encode the output state of the variable in time  $t+1$  with known  $k$  backstep values – the entropy of  $x_{t+1}$  – can be written as:

$$h_X(k) = -\sum p(x_{t+1}, x_t^{(k)}) \log_2 p(x_{t+1}|x_t^{(k)}) = H_X(x_{t+1}, x_t^{(k)}) - H_X(x_t^{(k)}) \quad (3)$$

where the summation runs over all the possible values of  $(x_{t+1}, x_t^{(k)})$ , for a fixed time  $t$  [55].

The value of the calculated entropy hence depends on the selection of the block length  $k$  – referred to as conditional block entropy – which decreases along the increase in the length of the block, as long as  $x_{t-k}$  contains more information to predict  $x_{t+1}$  than  $x_{t-k+1}$  [55].

For a bi-variate case, the value of transfer entropy can be obtained by accounting the deviation from the generalized Markov property. Considering a time series  $Y$ , the sequence of its observations until time  $t$ , with  $l$  back steps in time, can be taken as:

$$y_t^{(l)} = y_t, y_{t-1}, y_{t-2}, \dots, y_{t-l+1} \quad (4)$$

An information flow from process  $Y$  to process  $X$  exists, if the information in  $y_t^{(l)}$  can be valuable in forecasting  $x_{t+1}$ , despite the information collected from  $x_t^{(k)}$ . The transfer entropy,  $T_{Y \rightarrow X}(k, l)$ , is then formulated by Schreiber [48] as Equation 5, to subtract the information already contained in  $x_t^{(k)}$ :

$$T_{Y \rightarrow X}(k, l) = \sum_{x,y} p(x_{t+1}, x_t^{(k)}, y_t^{(l)}) \log_2 p(x_{t+1}|x_t^{(k)}, y_t^{(l)}) - \sum_x p(x_{t+1}, x_t^{(k)}) \log_2 p(x_{t+1}|x_t^{(k)}) \quad (5)$$

$$T_{Y \rightarrow X}(k, l) = h_X(k) - h_{X,Y}(k, l) \quad (6)$$

where  $h_{X,Y}(k, l)$  denotes the conditional entropy of  $X$ , given the information of both  $x_t^{(k)}$  and  $y_t^{(l)}$  blocks.

The results of the transfer entropy may be subject to bias, due to small-sample effects. To correct for this bias, it is suggested [52] to compute the effective transfer entropy,  $ETE_{Y \rightarrow X}(k, l)$ , between the two processes. The effective transfer entropy is calculated by subtracting the value of transfer entropy obtained from Equation 5 from the value obtained after conducting a shuffling operation on process  $Y$ ,  $T_{Y_{shuffled} \rightarrow X}(k, l)$ . The shuffling procedure entails taking random draws from the distribution of  $Y$  and re-arrangement of the selected set to generate a new time series, in order to destroy statistical dependencies between the two processes as well as the time series dependencies of  $Y$  [47]

$$ETE_{Y \rightarrow X}(k, l) = T_{Y \rightarrow X}(k, l) - T_{Y_{shuffled} \rightarrow X}(k, l) \quad (7)$$

$T_{Y_{shuffled} \rightarrow X}(k, l) \rightarrow 0$  as the sample size increases and becomes non-zero in case small-sample effects exist.

The set of probability measures listed above are established over discretized values of the variables; therefore, the variables' data should be grouped into non-overlapping partitions, a priori. For this reason, the symbolic encoding scheme dominantly used would select the size of the bins, according to the 5% and 95% empirical quantiles of the data –  $q_{[0.05]}$  and  $q_{[0.95]}$ . As a result, the symbolically-encoded time series,  $s_t$ , takes the following form:

$$s_t = \begin{cases} 1 \text{ for } y_t \leq q_{[0.05]} \\ 2 \text{ for } q_{[0.05]} < y_t < q_{[0.95]} \\ 3 \text{ for } y_t \geq q_{[0.95]} \end{cases} \quad (8)$$

In order to analyze the susceptibility of results to this choice of bin size, a different discretization scheme has also been tested in the present work, which incorporates more empirical quantiles of the data into its encoding system – Equation 9:

$$s_t = \begin{cases} 1 \text{ for } y_t \leq q_{[0.1]} \\ 2 \text{ for } q_{[0.1]} < y_t \leq q_{[0.2]} \\ 3 \text{ for } q_{[0.2]} < y_t \leq q_{[0.3]} \\ 4 \text{ for } q_{[0.3]} < y_t \leq q_{[0.4]} \\ 5 \text{ for } q_{[0.4]} < y_t \leq q_{[0.5]} \\ 6 \text{ for } q_{[0.5]} < y_t \leq q_{[0.6]} \\ 7 \text{ for } q_{[0.6]} < y_t \leq q_{[0.7]} \\ 8 \text{ for } q_{[0.7]} < y_t \leq q_{[0.8]} \\ 9 \text{ for } q_{[0.8]} < y_t \leq q_{[0.9]} \\ 10 \text{ for } y_t > q_{[0.9]} \end{cases} \quad (9)$$

### 3. Data Description

The information used as input in the present study, is comprised of the closing daily prices of stocks - belonging to a number of 2200 companies - being traded worldwide. Table 1 lists the names of the companies considered. The choice of the markets/indices was attempted to include the major global equity streams. The set of markets/indices considered is composed of Australian Stock Exchange (S&P ASX), Brazil Stock Exchange (BSE), Frankfurt Stock Exchange (FSE), Johannesburg Stock Exchange (JSE), Korean Stock Exchange (KSE), London Stock Exchange (FTSE), New York Stock Exchange (S&P500), Qatar Stock Exchange (QSE), Saudi Arabia Stock Exchange (SASE), Shanghai Stock Exchange (CSI), Tehran Stock Exchange (TSE), Tokyo Stock Exchange (Nikkei), and Toronto Stock Exchange (S&P TSX). The input data was obtained from Yahoo Finance, with the exception of TSE data, which was downloaded directly from the TSE data repository. The data was acquired for the time span between [2019-Aug-01 and 2021-Aug-01]. This length was later divided into two periods, to account for prior/post-COVID timelines. The date used to set this division was taken to be 30-January-2020, which is date on which the pandemic outbreak was officially declared by the World Health Organization [56].

**Table 1. The Yahoo ticker names of the stocks considered.**

Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
BSE	ABEV3.SA	BSE	BEEF3.SA	CSI	600958.SS
BSE	AZUL4.SA	BSE	MRVE3.SA	CSI	601939.SS
BSE	B3SA3.SA	BSE	MULT3.SA	CSI	601009.SS
BSE	BBAS3.SA	BSE	NTCO3.SA	CSI	601390.SS
BSE	BBSE3.SA	BSE	PETR3.SA	CSI	601006.SS
BSE	BBDC3.SA	BSE	PETR4.SA	CSI	601377.SS
BSE	BBDC4.SA	BSE	QUAL3.SA	CSI	600050.SS
BSE	BRAP4.SA	BSE	RADL3.SA	CSI	600795.SS
BSE	BRML3.SA	BSE	RAIL3.SA	CSI	601857.SS
BSE	BRKM5.SA	BSE	SBSPP3.SA	CSI	601628.SS
BSE	BRFS3.SA	BSE	SANB11.SA	CSI	601336.SS
BSE	BPAC11.SA	BSE	SULA11.SA	CSI	601899.SS
BSE	CRFB3.SA	BSE	SUZB3.SA	CSI	600547.SS
BSE	CCRO3.SA	BSE	TAE11.SA	CSI	600690.SS
BSE	CVCB3.SA	BSE	TOTS3.SA	CSI	600585.SS
BSE	CMIG4.SA	BSE	UGPA3.SA	CSI	600011.SS
BSE	HGTX3.SA	BSE	USIM5.SA	CSI	601985.SS
BSE	CIEL3.SA	BSE	VALE3.SA	CSI	600066.SS
BSE	COGN3.SA	BSE	VVAR3.SA	CSI	600637.SS
BSE	CSAN3.SA	BSE	YDUQ3.SA	CSI	601186.SS
BSE	CPFE3.SA	BSE	WEGE3.SA	CSI	600029.SS
BSE	CSNA3.SA	CSI	601318.SS	CSI	601088.SS
BSE	CYRE3.SA	CSI	600016.SS	CSI	601901.SS
BSE	ECOR3.SA	CSI	601166.SS	CSI	600111.SS
BSE	ENBR3.SA	CSI	600036.SS	CSI	601555.SS
BSE	ELET3.SA	CSI	601328.SS	CSI	600010.SS
BSE	ELET6.SA	CSI	600519.SS	CSI	600100.SS
BSE	EMBR3.SA	CSI	600000.SS	CSI	600570.SS
BSE	EGIE3.SA	CSI	600030.SS	CSI	600893.SS
BSE	EQTL3.SA	CSI	600837.SS	CSI	601099.SS
BSE	GGBR4.SA	CSI	601288.SS	CSI	600009.SS
BSE	GOLL4.SA	CSI	600887.SS	CSI	600115.SS
BSE	FLRY3.SA	CSI	601398.SS	CSI	601211.SS
BSE	HAPV3.SA	CSI	601169.SS	CSI	600271.SS

BSE	HYPE3.SA	CSI	600900.SS	CSI	600535.SS
BSE	IGTA3.SA	CSI	601668.SS	CSI	600705.SS
BSE	GNDI3.SA	CSI	601601.SS	CSI	600489.SS
BSE	IRBR3.SA	CSI	601766.SS	CSI	600703.SS
BSE	ITUB4.SA	CSI	600104.SS	CSI	600019.SS
BSE	ITSA4.SA	CSI	601988.SS	CSI	600196.SS
BSE	JBSS3.SA	CSI	600048.SS	CSI	600886.SS
BSE	KLBN11.SA	CSI	601818.SS	CSI	601669.SS
BSE	RENT3.SA	CSI	600276.SS	CSI	600089.SS
BSE	LAME4.SA	CSI	601688.SS	CSI	600109.SS
BSE	LREN3.SA	CSI	600015.SS	CSI	601607.SS
BSE	MGLU3.SA	CSI	600028.SS	CSI	601727.SS
BSE	MRFG3.SA	CSI	600518.SS	CSI	600177.SS
BSE	GOAU4.SA	CSI	600999.SS	CSI	600340.SS
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
CSI	600804.SS	CSI	600895.SS	CSI	600578.SS
CSI	601198.SS	CSI	601106.SS	CSI	600783.SS
CSI	601888.SS	CSI	601333.SS	CSI	600022.SS
CSI	600023.SS	CSI	600027.SS	CSI	600188.SS
CSI	600352.SS	CSI	600688.SS	CSI	603885.SS
CSI	600383.SS	CSI	601098.SS	CSI	600606.SS
CSI	600406.SS	CSI	601633.SS	FSE	DRI.DE
CSI	600649.SS	CSI	601718.SS	FSE	TGT.DE
CSI	600867.SS	CSI	601866.SS	FSE	2INV.DE
CSI	601111.SS	CSI	600170.SS	FSE	UUU.DE
CSI	600369.SS	CSI	600252.SS	FSE	VSC.DE
CSI	600674.SS	CSI	600362.SS	FSE	ARL.DE
CSI	600741.SS	CSI	600373.SS	FSE	A4Y.DE
CSI	601600.SS	CSI	600737.SS	FSE	APM.DE
CSI	600221.SS	CSI	600873.SS	FSE	ADS.DE
CSI	600309.SS	CSI	600875.SS	FSE	ADJ.DE
CSI	601788.SS	CSI	601021.SS	FSE	ADD.DE
CSI	601919.SS	CSI	601258.SS	FSE	ADL.DE
CSI	600068.SS	CSI	601991.SS	FSE	ADV.DE
CSI	600118.SS	CSI	600037.SS	FSE	AIR.DE
CSI	600153.SS	CSI	600376.SS	FSE	AIXA.DE
CSI	600739.SS	CSI	601117.SS	FSE	ASL.DE
CSI	601018.SS	CSI	601872.SS	FSE	A10S.DE
CSI	601933.SS	CSI	603000.SS	FSE	ALV.DE
CSI	600061.SS	CSI	600372.SS	FSE	ACT.DE
CSI	601618.SS	CSI	600704.SS	FSE	AAD.DE
CSI	601998.SS	CSI	601179.SS	FSE	AT1.DE
CSI	600018.SS	CSI	601898.SS	FSE	ART.DE
CSI	600085.SS	CSI	601992.SS	FSE	AOF.DE
CSI	600415.SS	CSI	600008.SS	FSE	AAG.DE
CSI	600718.SS	CSI	600021.SS	FSE	NDA.DE
CSI	600583.SS	CSI	600038.SS	FSE	AG1.DE
CSI	600588.SS	CSI	600827.SS	FSE	AVES.DE
CSI	600663.SS	CSI	601216.SS	FSE	BAS.DE
CSI	600816.SS	CSI	600863.SS	FSE	BSL.DE
CSI	600839.SS	CSI	600582.SS	FSE	BST.DE
CSI	601800.SS	CSI	600600.SS	FSE	B5A.DE
CSI	600150.SS	CSI	600666.SS	FSE	BMW3.DE
CSI	600398.SS	CSI	600959.SS	FSE	BMW.DE
CSI	600446.SS	CSI	601928.SS	FSE	BAYN.DE
CSI	603993.SS	CSI	601958.SS	FSE	BYW.DE
CSI	600157.SS	CSI	600648.SS	FSE	BYW6.DE
CSI	600208.SS	CSI	600685.SS	FSE	BBZA.DE
CSI	600820.SS	CSI	600871.SS	FSE	BC8.DE
CSI	600060.SS	CSI	600998.SS	FSE	BFS.DE
CSI	600256.SS	CSI	601608.SS	FSE	BEL.DE
CSI	600332.SS	CSI	601808.SS	FSE	BDT.DE
CSI	600642.SS	CSI	600098.SS	FSE	ACX.DE
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
FSE	GBF.DE	FSE	E4C.DE	FSE	HEN.DE
FSE	B8F.DE	FSE	ED4.DE	FSE	HLG.DE
FSE	BIO.DE	FSE	EIN3.DE	FSE	HOT.DE
FSE	BIO3.DE	FSE	ELG.DE	FSE	HOC.DE
FSE	BVB.DE	FSE	ZIL2.DE	FSE	H24.DE
FSE	BNN.DE	FSE	ELB.DE	FSE	HBM.DE
FSE	BNR.DE	FSE	ECX.DE	FSE	HBH.DE
FSE	COK.DE	FSE	ERWE.DE	FSE	BOSS.DE
FSE	CPX.DE	FSE	EVK.DE	FSE	HYQ.DE
FSE	AFX.DE	FSE	EVT.DE	FSE	INH.DE
FSE	CEC1.DE	FSE	EXC.DE	FSE	IFX.DE
FSE	CWC.DE	FSE	FAA.DE	FSE	IXX.DE
FSE	C0M.DE	FSE	FRU.DE	FSE	INS.DE
FSE	CBK.DE	FSE	FIE.DE	FSE	IS7.DE
FSE	COP.DE	FSE	SIS.DE	FSE	IVX.DE
FSE	CON.DE	FSE	FTK.DE	FSE	IVU.DE
FSE	CCAP.DE	FSE	FEV.DE	FSE	JEN.DE
FSE	1COV.DE	FSE	FPH.DE	FSE	JST.DE
FSE	CSQ.DE	FSE	FRA.DE	FSE	JUN3.DE
FSE	CE2.DE	FSE	FNTN.DE	FSE	SDF.DE
FSE	EVD.DE	FSE	FME.DE	FSE	IUR.DE
FSE	DAI.DE	FSE	FRE.DE	FSE	KGX.DE

FSE	DAM.DE	FSE	VH2.DE	FSE	KCO.DE
FSE	DHER.DE	FSE	FPE3.DE	FSE	KT.A.DE
FSE	DEX.DE	FSE	FPE.DE	FSE	KBX.DE
FSE	DMRE.DE	FSE	FBEN.DE	FSE	SKB.DE
FSE	DMP.DE	FSE	GTY.DE	FSE	KSC.DE
FSE	DBK.DE	FSE	G1A.DE	FSE	KRN.DE
FSE	DB1.DE	FSE	GME.DE	FSE	KU2.DE
FSE	DEQ.DE	FSE	GXI.DE	FSE	KWS.DE
FSE	DPW.DE	FSE	GSC1.DE	FSE	LXS.DE
FSE	DWNI.DE	FSE	GFT.DE	FSE	LEG.DE
FSE	DEZ.DE	FSE	GG.S.DE	FSE	LEI.DE
FSE	DFV.DE	FSE	GKS.DE	FSE	LEO.DE
FSE	DLG.DE	FSE	GFG.DE	FSE	LIN.DE
FSE	DIC.DE	FSE	GMM.DE	FSE	TGHN.DE
FSE	DBD.DE	FSE	GYC.DE	FSE	LPK.DE
FSE	GIL.DE	FSE	GLJ.DE	FSE	ECK.DE
FSE	HNL.DE	FSE	2HRA.DE	FSE	LHA.DE
FSE	DRW8.DE	FSE	690D.DE	FSE	MSZ.DE
FSE	DRW3.DE	FSE	HHFA.DE	FSE	MZX.DE
FSE	DBAN.DE	FSE	HNR1.DE	FSE	MXHN.DE
FSE	PBB.DE	FSE	HLAG.DE	FSE	MBB.DE
FSE	DTE.DE	FSE	HAW.DE	FSE	MED.DE
FSE	DUE.DE	FSE	HEI.DE	FSE	MDG1.DE
FSE	DWS.DE	FSE	HDD.DE	FSE	ILM1.DE
FSE	EOAN.DE	FSE	HLE.DE	FSE	MRK.DE
FSE	EUZ.DE	FSE	HFG.DE	FSE	B4B.DE
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
FSE	B4B3.DE	FSE	F3C.DE	FSE	V3V.DE
FSE	MLP.DE	FSE	SGL.DE	FSE	VOW.DE
FSE	MOR.DE	FSE	SAE.DE	FSE	VOW3.DE
FSE	MTX.DE	FSE	SIE.DE	FSE	VBX.DE
FSE	MUV2.DE	FSE	ENR.DE	FSE	VNA.DE
FSE	MVV1.DE	FSE	SHL.DE	FSE	VOS.DE
FSE	NA9.DE	FSE	WAF.DE	FSE	WCH.DE
FSE	NEM.DE	FSE	SNG.DE	FSE	WAC.DE
FSE	NWO.DE	FSE	LNSX.DE	FSE	WSU.DE
FSE	NXU.DE	FSE	SIX2.DE	FSE	WEW.DE
FSE	NFN.DE	FSE	SIX3.DE	FSE	WDL.DE
FSE	NDX1.DE	FSE	AM3D.DE	FSE	WUW.DE
FSE	NOEJ.DE	FSE	S92.DE	FSE	YOC.DE
FSE	OH.B.DE	FSE	SHF.DE	FSE	ZAL.DE
FSE	OSR.DE	FSE	SYT.DE	FSE	TIMA.DE
FSE	O4B.DE	FSE	SOW.DE	FSE	ZO1.DE
FSE	PA8.DE	FSE	STM.DE	FTSE	IILL
FSE	PGN.DE	FSE	SNH.DE	FTSE	ABDN.L
FSE	PAT.DE	FSE	S9L.DE	FTSE	ADM.L
FSE	O2C.DE	FSE	SBS.DE	FTSE	AAL.L
FSE	PFV.DE	FSE	SAX.DE	FTSE	ANTO.L
FSE	PSG.DE	FSE	SZU.DE	FTSE	AHT.L
FSE	PNE3.DE	FSE	SMHN.DE	FTSE	ABF.L
FSE	PCZ.DE	FSE	SUR.DE	FTSE	AZN.L
FSE	PWO.DE	FSE	SY1.DE	FTSE	AUTO.L
FSE	PSM.DE	FSE	SYAB.DE	FTSE	AVST.L
FSE	PSAN.DE	FSE	SYAB.DE	FTSE	AVV.L
FSE	PUM.DE	FSE	SYZ.DE	FTSE	AVL
FSE	TPE.DE	FSE	TEG.DE	FTSE	BME.L
FSE	QIA.DE	FSE	TTK.DE	FTSE	BAL
FSE	RSL2.DE	FSE	TLX.DE	FTSE	BARC.L
FSE	RAA.DE	FSE	TMV.DE	FTSE	BDEV.L
FSE	RHM.DE	FSE	TTR1.DE	FTSE	BKG.L
FSE	RHK.DE	FSE	TC1.DE	FTSE	BHP.L
FSE	RY8.DE	FSE	O2D.DE	FTSE	BPL
FSE	RRTL.DE	FSE	TLIK.DE	FTSE	BATS.L
FSE	RWE.DE	FSE	TKA.DE	FTSE	BLND.L
FSE	SANT.DE	FSE	8TRA.DE	FTSE	BNZLL
FSE	SFQ.DE	FSE	UN01.DE	FTSE	BRBY.L
FSE	SZG.DE	FSE	ULC.DE	FTSE	CCH.L
FSE	SAP.DE	FSE	OSP2.DE	FTSE	CPG.L
FSE	SRT.DE	FSE	UTDI.DE	FTSE	CRH.L
FSE	SRT3.DE	FSE	VTWR.DE	FTSE	CRDAL
FSE	SHA.DE	FSE	VQT.DE	FTSE	DCC.L
FSE	SLT.DE	FSE	VAR1.DE	FTSE	DGE.L
FSE	G24.DE	FSE	VBK.DE	FTSE	ENT.L
FSE	YSN.DE	FSE	VIB3.DE	FTSE	EVR.L
FSE	SJJ.DE	FSE	V6C.DE	FTSE	EXP.N.L
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
FTSE	FERG.L	FTSE	SMT.L	JSE	BTI.JO
FTSE	FLTR.L	FTSE	SGRO.L	JSE	CCO.JO
FTSE	FRES.L	FTSE	SVTL	JSE	CPI.JO
FTSE	GSK.L	FTSE	SMDS.L	JSE	CSB.JO
FTSE	GLEN.L	FTSE	SMIN.L	JSE	CAT.JO
FTSE	HLMA.L	FTSE	SN.L	JSE	CKS.JO
FTSE	HL.L	FTSE	SKG.L	JSE	DTC.JO
FTSE	HIK.L	FTSE	SPX.L	JSE	EMI.JO
FTSE	HSBA.L	FTSE	SSE.L	JSE	EPE.JO
FTSE	IHG.L	FTSE	STAN.L	JSE	EOH.JO

FTSE	IMB.L	FTSE	STJ.L	JSE	EXX.JO
FTSE	INFL	FTSE	TWL	JSE	FVT.JO
FTSE	ICPL	FTSE	TSCOL	JSE	FBR.JO
FTSE	IAG.L	FTSE	ULVRL	JSE	FSR.JO
FTSE	ITRK.L	FTSE	UU.L	JSE	TFG.JO
FTSE	ITVL	FTSE	VOD.L	JSE	GND.JO
FTSE	JD.L	FTSE	WEIR.L	JSE	HCL.JO
FTSE	JMAT.L	FTSE	WTB.L	JSE	HDC.JO
FTSE	JETL	FTSE	WPPL	JSE	INL.JO
FTSE	KGFL	JSE	ACS.JO	JSE	INP.JO
FTSE	LAND.L	JSE	ADI.JO	JSE	IVT.JO
FTSE	LGEN.L	JSE	AIP.JO	JSE	ISA.JO
FTSE	LLOY.L	JSE	ADR.JO	JSE	ITE.JO
FTSE	LSEG.L	JSE	ADH.JO	JSE	JSC.JO
FTSE	MNG.L	JSE	AFE.JO	JSE	JSE.JO
FTSE	MRO.L	JSE	AOO.JO	JSE	KAP.JO
FTSE	MNDI.L	JSE	ADW.JO	JSE	KIO.JO
FTSE	NG.L	JSE	AME.JO	JSE	LAB.JO
FTSE	NWG.L	JSE	ARI.JO	JSE	LEW.JO
FTSE	NXTL	JSE	AFT.JO	JSE	LBH.JO
FTSE	OCDO.L	JSE	ACT.JO	JSE	LHC.JO
FTSE	PSON.L	JSE	AFH.JO	JSE	OCT.JO
FTSE	PSH.L	JSE	ARH.JO	JSE	OMN.JO
FTSE	PSN.L	JSE	ACL.JO	JSE	OLG.JO
FTSE	PHNX.L	JSE	ART.JO	JSE	RACP.JO
FTSE	POLY.L	JSE	APN.JO	JSE	RBX.JO
FTSE	PRUL	JSE	ARL.JO	JSE	RDF.JO
FTSE	RKTL	JSE	AEG.JO	JSE	REM.JO
FTSE	RELL	JSE	AVI.JO	JSE	RES.JO
FTSE	RTOL	JSE	BAW.JO	JSE	RSJ.JO
FTSE	RMVL	JSE	BAU.JO	JSE	RLO.JO
FTSE	RIO.L	JSE	BEL.JO	JSE	RMH.JO
FTSE	RR.L	JSE	BVT.JO	JSE	RBP.JO
FTSE	RDSA.L	JSE	BLU.JO	JSE	SLM.JO
FTSE	RMG.L	JSE	BCF.JO	JSE	SNT.JO
FTSE	SGE.L	JSE	BAT.JO	JSE	SNV.JO
FTSE	SBRY.L	JSE	BIK.JO	JSE	SAP.JO
FTSE	SDRL	JSE	BRT.JO	JSE	SFN.JO
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
JSE	SOL.JO	KSE	161390.KS	KSE	214330.KS
KSE	244920.KS	KSE	123690.KS	KSE	339770.KS
KSE	140910.KS	KSE	128940.KS	KSE	214390.KS
KSE	298690.KS	KSE	105630.KS	KSE	267290.KS
KSE	161000.KS	KSE	213500.KS	KSE	115390.KS
KSE	183190.KS	KSE	272210.KS	KSE	108670.KS
KSE	267850.KS	KSE	294870.KS	KSE	280360.KS
KSE	155900.KS	KSE	322000.KS	KSE	286940.KS
KSE	282330.KS	KSE	172580.KS	KSE	330590.KS
KSE	352820.KS	KSE	153360.KS	KSE	229640.KS
KSE	138930.KS	KSE	111110.KS	KSE	900140.KS
KSE	308170.KS	KSE	298050.KS	KSE	204320.KS
KSE	100250.KS	KSE	298000.KS	KSE	357250.KS
KSE	185750.KS	KSE	298040.KS	KSE	134380.KS
KSE	120030.KS	KSE	298020.KS	KSE	138040.KS
KSE	109070.KS	KSE	267270.KS	KSE	268280.KS
KSE	192820.KS	KSE	227840.KS	KSE	204210.KS
KSE	264900.KS	KSE	267260.KS	KSE	107590.KS
KSE	112610.KS	KSE	126560.KS	KSE	251270.KS
KSE	192400.KS	KSE	267250.KS	KSE	181710.KS
KSE	284740.KS	KSE	307950.KS	KSE	138250.KS
KSE	353200.KS	KSE	350520.KS	KSE	271560.KS
KSE	117580.KS	KSE	334890.KS	KSE	950210.KS
KSE	128820.KS	KSE	249420.KS	KSE	103140.KS
KSE	145720.KS	KSE	103590.KS	KSE	102460.KS
KSE	139130.KS	KSE	122900.KS	KSE	100840.KS
KSE	375500.KS	KSE	101140.KS	KSE	145210.KS
KSE	282690.KS	KSE	214320.KS	KSE	207940.KS
KSE	170900.KS	KSE	129260.KS	KSE	272550.KS
KSE	102260.KS	KSE	226320.KS	KSE	101060.KS
KSE	241560.KS	KSE	175330.KS	KSE	102280.KS
KSE	336260.KS	KSE	271980.KS	KSE	248170.KS
KSE	192080.KS	KSE	272450.KS	KSE	200880.KS
KSE	163560.KS	KSE	194370.KS	KSE	134790.KS
KSE	192650.KS	KSE	234080.KS	KSE	123700.KS
KSE	155660.KS	KSE	123890.KS	KSE	326030.KS
KSE	210540.KS	KSE	105560.KS	KSE	285130.KS
KSE	139480.KS	KSE	119650.KS	KSE	210980.KS
KSE	365550.KS	KSE	344820.KS	KSE	248070.KS
KSE	133820.KS	KSE	281820.KS	KSE	336370.KS
KSE	114090.KS	KSE	130660.KS	KSE	306200.KS
KSE	241590.KS	KSE	104700.KS	KSE	136490.KS
KSE	195870.KS	KSE	161890.KS	KSE	145990.KS
KSE	101530.KS	KSE	120110.KS	KSE	214420.KS
KSE	293480.KS	KSE	144620.KS	KSE	363280.KS
KSE	143210.KS	KSE	138490.KS	KSE	100220.KS
KSE	300720.KS	KSE	357120.KS	KSE	105840.KS
KSE	180640.KS	KSE	145270.KS	KSE	118000.KS

Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
KSE	316140.KS	Nikkei	4503.T	Nikkei	6103.T
KSE	317400.KS	Nikkei	4519.T	Nikkei	6302.T
KSE	111770.KS	Nikkei	4568.T	Nikkei	6857.T
Nikkei	1332.T	Nikkei	4506.T	Nikkei	6770.T
Nikkei	1333.T	Nikkei	4523.T	Nikkei	7751.T
Nikkei	1605.T	Nikkei	4151.T	Nikkei	6952.T
Nikkei	1721.T	Nikkei	4578.T	Nikkei	7735.T
Nikkei	1808.T	Nikkei	4507.T	Nikkei	6902.T
Nikkei	1963.T	Nikkei	4502.T	Nikkei	6954.T
Nikkei	1812.T	Nikkei	5020.T	Nikkei	6504.T
Nikkei	1802.T	Nikkei	5019.T	Nikkei	6702.T
Nikkei	1928.T	Nikkei	5108.T	Nikkei	6674.T
Nikkei	1803.T	Nikkei	5101.T	Nikkei	6501.T
Nikkei	1801.T	Nikkei	5201.T	Nikkei	6971.T
Nikkei	2802.T	Nikkei	5333.T	Nikkei	6479.T
Nikkei	2502.T	Nikkei	5214.T	Nikkei	6503.T
Nikkei	2914.T	Nikkei	5202.T	Nikkei	6701.T
Nikkei	2801.T	Nikkei	5232.T	Nikkei	3105.T
Nikkei	2503.T	Nikkei	5233.T	Nikkei	6645.T
Nikkei	2269.T	Nikkei	5301.T	Nikkei	6752.T
Nikkei	2871.T	Nikkei	5332.T	Nikkei	7752.T
Nikkei	2282.T	Nikkei	5411.T	Nikkei	6724.T
Nikkei	2002.T	Nikkei	5406.T	Nikkei	6753.T
Nikkei	2501.T	Nikkei	5401.T	Nikkei	6758.T
Nikkei	2531.T	Nikkei	5541.T	Nikkei	6976.T
Nikkei	3401.T	Nikkei	5714.T	Nikkei	6762.T
Nikkei	3402.T	Nikkei	5803.T	Nikkei	8035.T
Nikkei	3101.T	Nikkei	5801.T	Nikkei	6506.T
Nikkei	3103.T	Nikkei	5711.T	Nikkei	6841.T
Nikkei	3863.T	Nikkei	5706.T	Nikkei	7012.T
Nikkei	3861.T	Nikkei	5703.T	Nikkei	7003.T
Nikkei	3407.T	Nikkei	3436.T	Nikkei	7205.T
Nikkei	4061.T	Nikkei	5802.T	Nikkei	7267.T
Nikkei	4631.T	Nikkei	5713.T	Nikkei	7202.T
Nikkei	4901.T	Nikkei	5707.T	Nikkei	7261.T
Nikkei	4452.T	Nikkei	5901.T	Nikkei	7211.T
Nikkei	3405.T	Nikkei	6113.T	Nikkei	7201.T
Nikkei	4188.T	Nikkei	6367.T	Nikkei	7270.T
Nikkei	4183.T	Nikkei	6361.T	Nikkei	7269.T
Nikkei	4021.T	Nikkei	6305.T	Nikkei	7203.T
Nikkei	6988.T	Nikkei	7004.T	Nikkei	7272.T
Nikkei	4063.T	Nikkei	5631.T	Nikkei	7762.T
Nikkei	4911.T	Nikkei	6473.T	Nikkei	4902.T
Nikkei	4004.T	Nikkei	6301.T	Nikkei	7731.T
Nikkei	4005.T	Nikkei	6326.T	Nikkei	7733.T
Nikkei	4043.T	Nikkei	7011.T	Nikkei	4543.T
Nikkei	4042.T	Nikkei	6471.T	Nikkei	8001.T
Nikkei	4208.T	Nikkei	6472.T	Nikkei	8002.T
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
Nikkei	8058.T	Nikkei	9005.T	QSE	GWCS.QA
Nikkei	8031.T	Nikkei	9021.T	QSE	QIMD.QA
Nikkei	2768.T	Nikkei	9062.T	QSE	IQCD.QA
Nikkei	8053.T	Nikkei	9064.T	QSE	QIHK.QA
Nikkei	8015.T	Nikkei	9107.T	QSE	IGRD.QA
Nikkei	7832.T	Nikkei	9104.T	QSE	QIGD.QA
Nikkei	7912.T	Nikkei	9101.T	QSE	IHGS.QA
Nikkei	7911.T	Nikkei	9202.T	QSE	QISL.QA
Nikkei	7951.T	Nikkei	9301.T	QSE	MCCS.QA
Nikkei	8267.T	Nikkei	9433.T	QSE	MRDS.QA
Nikkei	9983.T	Nikkei	9432.T	QSE	MCGS.QA
Nikkei	3099.T	Nikkei	9613.T	QSE	MPHC.QA
Nikkei	3086.T	Nikkei	9412.T	QSE	QGTS.QA
Nikkei	8252.T	Nikkei	9434.T	QSE	QNCD.QA
Nikkei	3382.T	Nikkei	9984.T	QSE	NLCS.QA
Nikkei	8233.T	Nikkei	9502.T	QSE	ORDS.QA
Nikkei	8304.T	Nikkei	9503.T	QSE	QFBQ.QA
Nikkei	8331.T	Nikkei	9501.T	QSE	QFLS.QA
Nikkei	7186.T	Nikkei	9532.T	QSE	QGMD.QA
Nikkei	8309.T	Nikkei	9531.T	QSE	QATI.QA
Nikkei	8354.T	Nikkei	4751.T	QSE	QIBK.QA
Nikkei	8306.T	Nikkei	2432.T	QSE	QNNNS.QA
Nikkei	8411.T	Nikkei	4324.T	QSE	QOIS.QA
Nikkei	8308.T	Nikkei	6178.T	QSE	QNBK.QA
Nikkei	8303.T	Nikkei	9766.T	QSE	MARK.QA
Nikkei	8355.T	Nikkei	2413.T	QSE	SIIS.QA
Nikkei	8316.T	Nikkei	3659.T	QSE	UDCD.QA
Nikkei	8601.T	Nikkei	4755.T	QSE	VFQS.QA
Nikkei	8628.T	Nikkei	6098.T	QSE	WDAM.QA
Nikkei	8604.T	Nikkei	9735.T	QSE	ZHCD.QA
Nikkei	8750.T	Nikkei	9602.T	SASE	4001.SR
Nikkei	8725.T	Nikkei	4704.T	SASE	4191.SR
Nikkei	8630.T	Nikkei	4689.T	SASE	1820.SR
Nikkei	8795.T	QSE	AHCS.QA	SASE	2330.SR
Nikkei	8766.T	QSE	ABQK.QA	SASE	2340.SR
Nikkei	8253.T	QSE	AKHI.QA	SASE	8280.SR



Nikkei	8697.T	QSE	KCBK.QA	SASE	4130.SR
Nikkei	8802.T	QSE	MERS.QA	SASE	6020.SR
Nikkei	8801.T	QSE	BRES.QA	SASE	4007.SR
Nikkei	8830.T	QSE	QCFS.QA	SASE	1214.SR
Nikkei	8804.T	QSE	CBQK.QA	SASE	6070.SR
Nikkei	3289.T	QSE	DBIS.QA	SASE	3091.SR
Nikkei	9022.T	QSE	DHBK.QA	SASE	3008.SR
Nikkei	9020.T	QSE	DOHI.QA	SASE	4290.SR
Nikkei	9008.T	QSE	QEWS.QA	SASE	4141.SR
Nikkei	9009.T	QSE	ERES.QA	SASE	1120.SR
Nikkei	9007.T	QSE	QGRI.QA	SASE	8230.SR
Nikkei	9001.T	QSE	GISS.QA	SASE	8180.SR
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
SASE	1304.SR	SASE	3080.SR	SASE	4230.SR
SASE	8130.SR	SASE	1303.SR	SASE	1010.SR
SASE	4320.SR	SASE	4220.SR	SASE	4330.SR
SASE	2320.SR	SASE	7040.SR	SASE	9512.SR
SASE	4200.SR	SASE	7020.SR	SASE	8080.SR
SASE	8170.SR	SASE	4240.SR	SASE	2020.SR
SASE	1150.SR	SASE	2180.SR	SASE	1832.SR
SASE	8312.SR	SASE	4180.SR	SASE	2310.SR
SASE	4331.SR	SASE	8260.SR	SASE	8050.SR
SASE	8012.SR	SASE	8120.SR	SASE	2120.SR
SASE	2081.SR	SASE	3001.SR	SASE	6004.SR
SASE	8040.SR	SASE	6001.SR	SASE	2030.SR
SASE	8150.SR	SASE	6002.SR	SASE	2160.SR
SASE	2280.SR	SASE	4250.SR	SASE	8100.SR
SASE	2170.SR	SASE	4190.SR	SASE	1211.SR
SASE	8310.SR	SASE	6090.SR	SASE	2222.SR
SASE	1182.SR	SASE	4280.SR	SASE	4050.SR
SASE	4061.SR	SASE	4310.SR	SASE	2010.SR
SASE	1080.SR	SASE	4011.SR	SASE	1060.SR
SASE	7201.SR	SASE	1830.SR	SASE	3030.SR
SASE	8160.SR	SASE	4100.SR	SASE	2040.SR
SASE	3010.SR	SASE	8020.SR	SASE	2230.SR
SASE	2200.SR	SASE	8030.SR	SASE	4008.SR
SASE	8070.SR	SASE	2001.SR	SASE	5110.SR
SASE	4150.SR	SASE	4009.SR	SASE	8311.SR
SASE	4080.SR	SASE	1202.SR	SASE	6050.SR
SASE	6060.SR	SASE	2370.SR	SASE	4031.SR
SASE	1212.SR	SASE	7030.SR	SASE	2130.SR
SASE	8250.SR	SASE	4002.SR	SASE	4140.SR
SASE	2140.SR	SASE	4336.SR	SASE	2250.SR
SASE	4051.SR	SASE	3002.SR	SASE	2190.SR
SASE	1140.SR	SASE	2210.SR	SASE	1030.SR
SASE	1020.SR	SASE	1213.SR	SASE	2350.SR
SASE	1050.SR	SASE	6010.SR	SASE	4006.SR
SASE	1210.SR	SASE	9510.SR	SASE	1180.SR
SASE	4110.SR	SASE	2150.SR	SASE	2300.SR
SASE	1302.SR	SASE	4291.SR	SASE	2070.SR
SASE	4161.SR	SASE	2080.SR	SASE	4270.SR
SASE	8210.SR	SASE	2090.SR	SASE	4040.SR
SASE	8270.SR	SASE	2060.SR	SASE	4020.SR
SASE	8240.SR	SASE	4005.SR	SASE	8200.SR
SASE	3003.SR	SASE	2220.SR	SASE	4210.SR
SASE	8010.SR	SASE	2002.SR	SASE	1320.SR
SASE	4004.SR	SASE	4030.SR	SASE	7010.SR
SASE	4300.SR	SASE	3004.SR	SASE	2360.SR
SASE	9501.SR	SASE	3040.SR	SASE	2270.SR
SASE	4013.SR	SASE	2380.SR	SASE	2050.SR
SASE	4010.SR	SASE	6012.SR	SASE	4344.SR
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
SASE	1810.SR	S&P500	GOOG	S&P500	BSX
SASE	3050.SR	S&P500	MO	S&P500	BMJ
SASE	9511.SR	S&P500	AMZN	S&P500	AVGO
SASE	6040.SR	S&P500	AMCR	S&P500	BR
SASE	3090.SR	S&P500	AEE	S&P500	CHRW
SASE	4090.SR	S&P500	AAL	S&P500	COG
SASE	1201.SR	S&P500	AEP	S&P500	CDNS
SASE	4012.SR	S&P500	AXP	S&P500	CZR
SASE	4070.SR	S&P500	AIG	S&P500	CPB
SASE	4170.SR	S&P500	AMT	S&P500	COF
SASE	3005.SR	S&P500	AWK	S&P500	CAH
SASE	8190.SR	S&P500	AMP	S&P500	KMX
SASE	4003.SR	S&P500	ABC	S&P500	CCL
SASE	4260.SR	S&P500	AME	S&P500	CARR
SASE	1301.SR	S&P500	AMGN	S&P500	CTLT
SASE	8060.SR	S&P500	APH	S&P500	CAT
SASE	9513.SR	S&P500	ADI	S&P500	CBOE
SASE	8300.SR	S&P500	ANSS	S&P500	CBRE
SASE	3020.SR	S&P500	ANTM	S&P500	CDW
SASE	3060.SR	S&P500	AON	S&P500	CE
SASE	2290.SR	S&P500	APA	S&P500	CNC
SASE	3007.SR	S&P500	AAPL	S&P500	CNP
SASE	2240.SR	S&P500	AMAT	S&P500	CERN
S&P500	MMM	S&P500	APTV	S&P500	CF

S&P500	AOS	S&P500	ANET	S&P500	CRL
S&P500	ABT	S&P500	AJG	S&P500	SCHW
S&P500	ABBV	S&P500	AIZ	S&P500	CHTR
S&P500	ABMD	S&P500	T	S&P500	CVX
S&P500	ACN	S&P500	ATO	S&P500	CMG
S&P500	ATVI	S&P500	ADSK	S&P500	CB
S&P500	ADM	S&P500	ADP	S&P500	CHD
S&P500	ADBE	S&P500	AZO	S&P500	CI
S&P500	AAP	S&P500	AVB	S&P500	CINF
S&P500	AMD	S&P500	AVY	S&P500	CTAS
S&P500	AES	S&P500	BKR	S&P500	CSCO
S&P500	AFL	S&P500	BLI	S&P500	C
S&P500	A	S&P500	BAC	S&P500	CFG
S&P500	APD	S&P500	BAX	S&P500	CTXS
S&P500	AKAM	S&P500	BDX	S&P500	CLX
S&P500	ALK	S&P500	BBY	S&P500	CME
S&P500	ALB	S&P500	BIO	S&P500	CMS
S&P500	ARE	S&P500	BIIB	S&P500	KO
S&P500	ALXN	S&P500	BLK	S&P500	CTSH
S&P500	ALGN	S&P500	BK	S&P500	CL
S&P500	ALLE	S&P500	BA	S&P500	CMCSA
S&P500	LNT	S&P500	BKNG	S&P500	CMA
S&P500	ALL	S&P500	BWA	S&P500	CAG
S&P500	GOOGL	S&P500	BXP	S&P500	COP
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
S&P500	ED	S&P500	EFX	S&P500	HBI
S&P500	STZ	S&P500	EQIX	S&P500	HAS
S&P500	CPRT	S&P500	EQR	S&P500	HCA
S&P500	GLW	S&P500	ESS	S&P500	PEAK
S&P500	CTVA	S&P500	EL	S&P500	HSIC
S&P500	COST	S&P500	ETSY	S&P500	HES
S&P500	CCI	S&P500	RE	S&P500	HPE
S&P500	CSX	S&P500	EVRG	S&P500	HLT
S&P500	CMI	S&P500	ES	S&P500	HOLX
S&P500	CVS	S&P500	EXC	S&P500	HD
S&P500	DHI	S&P500	EXPE	S&P500	HON
S&P500	DHR	S&P500	EXPD	S&P500	HRL
S&P500	DRI	S&P500	EXR	S&P500	HST
S&P500	DVA	S&P500	XOM	S&P500	HWM
S&P500	DE	S&P500	FFIV	S&P500	HPQ
S&P500	DAL	S&P500	FB	S&P500	HUM
S&P500	XRAY	S&P500	FAST	S&P500	HBAN
S&P500	DVN	S&P500	FRT	S&P500	HII
S&P500	DXCM	S&P500	FDX	S&P500	IBM
S&P500	FANG	S&P500	FIS	S&P500	IEX
S&P500	DLR	S&P500	FITB	S&P500	IDXX
S&P500	DFS	S&P500	FRC	S&P500	INFO
S&P500	DISCA	S&P500	FE	S&P500	ITW
S&P500	DISCK	S&P500	FISV	S&P500	ILMN
S&P500	DISH	S&P500	FLT	S&P500	INCY
S&P500	DG	S&P500	FMC	S&P500	IR
S&P500	DLTR	S&P500	F	S&P500	INTC
S&P500	D	S&P500	FTNT	S&P500	ICE
S&P500	DPZ	S&P500	FTV	S&P500	IFF
S&P500	DOV	S&P500	FBHS	S&P500	IP
S&P500	DOW	S&P500	FOXA	S&P500	IPG
S&P500	DTE	S&P500	FOX	S&P500	INTU
S&P500	DUK	S&P500	BEN	S&P500	ISRG
S&P500	DRE	S&P500	FCX	S&P500	IVZ
S&P500	DD	S&P500	GPS	S&P500	IPGP
S&P500	DXC	S&P500	GRMN	S&P500	IQV
S&P500	EMN	S&P500	IT	S&P500	IRM
S&P500	ETN	S&P500	GNRC	S&P500	JBHT
S&P500	EBAY	S&P500	GD	S&P500	JKHY
S&P500	ECL	S&P500	GE	S&P500	J
S&P500	EIX	S&P500	GIS	S&P500	SJM
S&P500	EW	S&P500	GM	S&P500	JNJ
S&P500	EA	S&P500	GPC	S&P500	JCI
S&P500	LLY	S&P500	GILD	S&P500	JPM
S&P500	EMR	S&P500	GP	S&P500	JNPR
S&P500	ENPH	S&P500	GL	S&P500	KSU
S&P500	ETR	S&P500	GS	S&P500	K
S&P500	EOG	S&P500	HAL	S&P500	KEY
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
S&P500	KEYS	S&P500	TAP	S&P500	PKI
S&P500	KMB	S&P500	MDLZ	S&P500	PRGO
S&P500	KIM	S&P500	MPWR	S&P500	PFE
S&P500	KMI	S&P500	MNST	S&P500	PM
S&P500	KLAC	S&P500	MCO	S&P500	PSX
S&P500	KHC	S&P500	MS	S&P500	PNW
S&P500	KR	S&P500	MSI	S&P500	PXD
S&P500	LB	S&P500	MSCI	S&P500	PNC
S&P500	LHX	S&P500	NDAQ	S&P500	POOL
S&P500	LH	S&P500	NTAP	S&P500	PPG
S&P500	LRCX	S&P500	NFLX	S&P500	PPL
S&P500	LW	S&P500	NWL	S&P500	PFG

S&P500	LVS	S&P500	NEM	S&P500	PG
S&P500	LEG	S&P500	NWSA	S&P500	PGR
S&P500	LDOS	S&P500	NWS	S&P500	PLD
S&P500	LEN	S&P500	NEE	S&P500	PRU
S&P500	LNC	S&P500	NLSN	S&P500	PTC
S&P500	LIN	S&P500	NKE	S&P500	PEG
S&P500	LYV	S&P500	NI	S&P500	PSA
S&P500	LKQ	S&P500	NSC	S&P500	PHM
S&P500	LMT	S&P500	NTRS	S&P500	PVH
S&P500	L	S&P500	NOC	S&P500	QRVO
S&P500	LOW	S&P500	NLOK	S&P500	QCOM
S&P500	LUMN	S&P500	NCLH	S&P500	PWR
S&P500	LYB	S&P500	NOV	S&P500	DGX
S&P500	MTB	S&P500	NRG	S&P500	RL
S&P500	MRO	S&P500	NUE	S&P500	RJF
S&P500	MPC	S&P500	NVDA	S&P500	RTX
S&P500	MKTX	S&P500	NVR	S&P500	O
S&P500	MAR	S&P500	NXPI	S&P500	REG
S&P500	MMC	S&P500	ORLY	S&P500	REGN
S&P500	MLM	S&P500	OXY	S&P500	RF
S&P500	MAS	S&P500	ODFL	S&P500	RSG
S&P500	MA	S&P500	OMC	S&P500	RMD
S&P500	MXIM	S&P500	OKE	S&P500	RHI
S&P500	MKC	S&P500	ORCL	S&P500	ROK
S&P500	MCD	S&P500	OGN	S&P500	ROL
S&P500	MCK	S&P500	OTIS	S&P500	ROP
S&P500	MDT	S&P500	PCAR	S&P500	ROST
S&P500	MRK	S&P500	PKG	S&P500	RCL
S&P500	MET	S&P500	PH	S&P500	SPGI
S&P500	MTD	S&P500	PAYX	S&P500	CRM
S&P500	MGM	S&P500	PAYC	S&P500	SBAC
S&P500	MCHP	S&P500	PYPL	S&P500	SLB
S&P500	MU	S&P500	PENN	S&P500	STX
S&P500	MSFT	S&P500	PNR	S&P500	SEE
S&P500	MAA	S&P500	PBCT	S&P500	SRE
S&P500	MHK	S&P500	PEP	S&P500	NOW
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
S&P500	SHW	S&P500	UNP	S&P ASX	AGL.AX
S&P500	SPG	S&P500	UAL	S&P ASX	AIA.AX
S&P500	SWKS	S&P500	UPS	S&P ASX	ALD.AX
S&P500	SNA	S&P500	URI	S&P ASX	ALL.AX
S&P500	SO	S&P500	UNH	S&P ASX	ALQ.AX
S&P500	LUV	S&P500	UHS	S&P ASX	ALU.AX
S&P500	SWK	S&P500	UNM	S&P ASX	ALX.AX
S&P500	SBUX	S&P500	VLO	S&P ASX	AMC.AX
S&P500	STT	S&P500	VTR	S&P ASX	AMP.AX
S&P500	STE	S&P500	VRSN	S&P ASX	ANN.AX
S&P500	SYK	S&P500	VRSK	S&P ASX	ANZ.AX
S&P500	SIVB	S&P500	VZ	S&P ASX	APA.AX
S&P500	SYF	S&P500	VRTX	S&P ASX	APE.AX
S&P500	SNPS	S&P500	VFC	S&P ASX	APT.AX
S&P500	SYI	S&P500	VIAC	S&P ASX	APX.AX
S&P500	TMUS	S&P500	VTRS	S&P ASX	ARB.AX
S&P500	TROW	S&P500	V	S&P ASX	AST.AX
S&P500	TTWO	S&P500	VNO	S&P ASX	ASX.AX
S&P500	TPR	S&P500	VMC	S&P ASX	AUB.AX
S&P500	TGT	S&P500	WRB	S&P ASX	AWC.AX
S&P500	TEL	S&P500	GWV	S&P ASX	AZJ.AX
S&P500	TDY	S&P500	WAB	S&P ASX	BAP.AX
S&P500	TFX	S&P500	WBA	S&P ASX	BEN.AX
S&P500	TER	S&P500	WMT	S&P ASX	BGA.AX
S&P500	TSLA	S&P500	WM	S&P ASX	BHP.AX
S&P500	TXN	S&P500	WAT	S&P ASX	BKL.AX
S&P500	TXT	S&P500	WEC	S&P ASX	BKW.AX
S&P500	COO	S&P500	WFC	S&P ASX	BLD.AX
S&P500	HIG	S&P500	WELL	S&P ASX	BOQ.AX
S&P500	HSY	S&P500	WST	S&P ASX	BPT.AX
S&P500	MOS	S&P500	WDC	S&P ASX	BRG.AX
S&P500	TRV	S&P500	WU	S&P ASX	BSL.AX
S&P500	DIS	S&P500	WRK	S&P ASX	BWP.AX
S&P500	TMO	S&P500	WY	S&P ASX	BXB.AX
S&P500	TJX	S&P500	WHR	S&P ASX	CAR.AX
S&P500	TSCO	S&P500	WMB	S&P ASX	CBA.AX
S&P500	TT	S&P500	WLTW	S&P ASX	CCP.AX
S&P500	TDG	S&P500	WYNN	S&P ASX	CDA.AX
S&P500	TRMB	S&P500	XEL	S&P ASX	CGC.AX
S&P500	TFC	S&P500	XLNX	S&P ASX	CGF.AX
S&P500	TWTR	S&P500	XYL	S&P ASX	CHC.AX
S&P500	TYL	S&P500	YUM	S&P ASX	CHN.AX
S&P500	TSN	S&P500	ZBRA	S&P ASX	CIA.AX
S&P500	USB	S&P500	ZBH	S&P ASX	CIM.AX
S&P500	UDR	S&P500	ZION	S&P ASX	CIP.AX
S&P500	ULTA	S&P500	ZTS	S&P ASX	CKF.AX
S&P500	UAA	S&P ASX	ABC.AX	S&P ASX	CLW.AX
S&P500	UA	S&P ASX	ABP.AX	S&P ASX	CMW.AX

Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
S&P ASX	CNI.AX	S&P ASX	JHX.AX	S&P ASX	RBL.AX
S&P ASX	CNU.AX	S&P ASX	KGN.AX	S&P ASX	REA.AX
S&P ASX	COH.AX	S&P ASX	LLC.AX	S&P ASX	REH.AX
S&P ASX	COL.AX	S&P ASX	LNK.AX	S&P ASX	RHC.AX
S&P ASX	CPU.AX	S&P ASX	LYC.AX	S&P ASX	RIO.AX
S&P ASX	CQR.AX	S&P ASX	MFG.AX	S&P ASX	RMD.AX
S&P ASX	CSL.AX	S&P ASX	MGR.AX	S&P ASX	RMS.AX
S&P ASX	CSR.AX	S&P ASX	MIN.AX	S&P ASX	RRL.AX
S&P ASX	CTD.AX	S&P ASX	MND.AX	S&P ASX	RWC.AX
S&P ASX	CUV.AX	S&P ASX	MP1.AX	S&P ASX	S32.AX
S&P ASX	CWN.AX	S&P ASX	MPL.AX	S&P TSX	ARE.TO
S&P ASX	CWY.AX	S&P ASX	MQG.AX	S&P TSX	AEM.TO
S&P ASX	DHG.AX	S&P ASX	MSB.AX	S&P TSX	AC.TO
S&P ASX	DMP.AX	S&P ASX	MTS.AX	S&P TSX	AGI.TO
S&P ASX	DOW.AX	S&P ASX	NAB.AX	S&P TSX	AQN.TO
S&P ASX	DRR.AX	S&P ASX	NAN.AX	S&P TSX	ALA.TO
S&P ASX	DXS.AX	S&P ASX	NCM.AX	S&P TSX	AIF.TO
S&P ASX	EDV.AX	S&P ASX	NEA.AX	S&P TSX	ARX.TO
S&P ASX	ELD.AX	S&P ASX	NEC.AX	S&P TSX	ATZ.TO
S&P ASX	EML.AX	S&P ASX	NHF.AX	S&P TSX	ATA.TO
S&P ASX	EVN.AX	S&P ASX	NIC.AX	S&P TSX	AUP.TO
S&P ASX	FBU.AX	S&P ASX	NSR.AX	S&P TSX	ACB.TO
S&P ASX	FLT.AX	S&P ASX	NST.AX	S&P TSX	BTO.TO
S&P ASX	FMG.AX	S&P ASX	NUF.AX	S&P TSX	BDGI.TO
S&P ASX	FPH.AX	S&P ASX	NWH.AX	S&P TSX	BLDP.TO
S&P ASX	GEM.AX	S&P ASX	NWL.AX	S&P TSX	BMO.TO
S&P ASX	GMG.AX	S&P ASX	NWS.AX	S&P TSX	BNS.TO
S&P ASX	GNC.AX	S&P ASX	NXL.AX	S&P TSX	ABX.TO
S&P ASX	GOR.AX	S&P ASX	NXT.AX	S&P TSX	BHC.TO
S&P ASX	GOZ.AX	S&P ASX	OBL.AX	S&P TSX	BCE.TO
S&P ASX	GPT.AX	S&P ASX	ORA.AX	S&P TSX	BB.TO
S&P ASX	GUD.AX	S&P ASX	ORE.AX	S&P TSX	BLX.TO
S&P ASX	HLS.AX	S&P ASX	ORG.AX	S&P TSX	BYD.TO
S&P ASX	HUB.AX	S&P ASX	ORI.AX	S&P TSX	DOO.TO
S&P ASX	HVN.AX	S&P ASX	OSH.AX	S&P TSX	CAE.TO
S&P ASX	IAG.AX	S&P ASX	OZL.AX	S&P TSX	CCO.TO
S&P ASX	IEL.AX	S&P ASX	PBH.AX	S&P TSX	CF.TO
S&P ASX	IFL.AX	S&P ASX	PDL.AX	S&P TSX	GOOS.TO
S&P ASX	IGO.AX	S&P ASX	PLS.AX	S&P TSX	CM.TO
S&P ASX	ILU.AX	S&P ASX	PME.AX	S&P TSX	CNR.TO
S&P ASX	INA.AX	S&P ASX	PMV.AX	S&P TSX	CNQ.TO
S&P ASX	ING.AX	S&P ASX	PNV.AX	S&P TSX	CP.TO
S&P ASX	IPH.AX	S&P ASX	PPT.AX	S&P TSX	CU.TO
S&P ASX	IPL.AX	S&P ASX	PRU.AX	S&P TSX	CWB.TO
S&P ASX	IRE.AX	S&P ASX	PTM.AX	S&P TSX	CFP.TO
S&P ASX	IVC.AX	S&P ASX	QAN.AX	S&P TSX	WEED.TO
S&P ASX	JBH.AX	S&P ASX	QBE.AX	S&P TSX	CPX.TO
S&P ASX	JHG.AX	S&P ASX	QUB.AX	S&P TSX	CS.TO
Market/Index	Yahoo ticker	Market/Index	Yahoo ticker	Market/Index	Yahoo ticker
S&P TSX	CJT.TO	S&P TSX	IMO.TO	S&P TSX	PSK.TO
S&P TSX	CAS.TO	S&P TSX	INE.TO	S&P TSX	PBH.TO
S&P TSX	CLS.TO	S&P TSX	IFC.TO	S&P TSX	PVG.TO
S&P TSX	CVE.TO	S&P TSX	IPL.TO	S&P TSX	PRMW.TO
S&P TSX	CG.TO	S&P TSX	IFPTO	S&P TSX	REAL.TO
S&P TSX	CIX.TO	S&P TSX	ITPTO	S&P TSX	QSR.TO
S&P TSX	CCA.TO	S&P TSX	IVN.TO	S&P TSX	RCH.TO
S&P TSX	CIGI.TO	S&P TSX	JWEL.TO	S&P TSX	RBA.TO
S&P TSX	CSU.TO	S&P TSX	KEY.TO	S&P TSX	RY.TO
S&P TSX	CPG.TO	S&P TSX	KXS.TO	S&P TSX	RUS.TO
S&P TSX	CRON.TO	S&P TSX	K.TO	S&P TSX	SSL.TO
S&P TSX	DML.TO	S&P TSX	KL.TO	S&P TSX	SAP.TO
S&P TSX	DSG.TO	S&P TSX	LIFTO	S&P TSX	SEA.TO
S&P TSX	DOL.TO	S&P TSX	LB.TO	S&P TSX	SHOP.TO
S&P TSX	DPM.TO	S&P TSX	LWRK.TO	S&P TSX	SIA.TO
S&P TSX	DND.TO	S&P TSX	LSPD.TO	S&P TSX	SVM.TO
S&P TSX	ECN.TO	S&P TSX	LNR.TO	S&P TSX	SIL.TO
S&P TSX	ELD.TO	S&P TSX	LAC.TO	S&P TSX	ZZZ.TO
S&P TSX	EFN.TO	S&P TSX	L.TO	S&P TSX	SNC.TO
S&P TSX	EMA.TO	S&P TSX	LUN.TO	S&P TSX	TOY.TO
S&P TSX	ENB.TO	S&P TSX	MAG.TO	S&P TSX	SHI.TO
S&P TSX	EDR.TO	S&P TSX	MG.TO	S&P TSX	SSRM.TO
S&P TSX	ERF.TO	S&P TSX	MFC.TO	S&P TSX	STN.TO
S&P TSX	ENGH.TO	S&P TSX	MFI.TO	S&P TSX	STLC.TO
S&P TSX	EQX.TO	S&P TSX	MRE.TO	S&P TSX	SJ.TO
S&P TSX	EQB.TO	S&P TSX	MEG.TO	S&P TSX	SLF.TO
S&P TSX	ERO.TO	S&P TSX	MX.TO	S&P TSX	SU.TO
S&P TSX	EIF.TO	S&P TSX	MRU.TO	S&P TSX	SOY.TO
S&P TSX	FFH.TO	S&P TSX	MTL.TO	S&P TSX	SPB.TO
S&P TSX	FTT.TO	S&P TSX	NA.TO	S&P TSX	TRP.TO
S&P TSX	FR.TO	S&P TSX	NGD.TO	S&P TSX	T.TO
S&P TSX	FM.TO	S&P TSX	NXE.TO	S&P TSX	TFIL.TO
S&P TSX	FSV.TO	S&P TSX	NFI.TO	S&P TSX	NWC.TO
S&P TSX	FTS.TO	S&P TSX	NPI.TO	S&P TSX	TRI.TO
S&P TSX	FVI.TO	S&P TSX	NG.TO	S&P TSX	X.TO
S&P TSX	FNV.TO	S&P TSX	NTR.TO	S&P TSX	TXG.TO

S&P TSX	WN.TO	S&P TSX	NVEI.TO	S&P TSX	TIH.TO
S&P TSX	GFL.TO	S&P TSX	OGC.TO	S&P TSX	TD.TO
S&P TSX	GEL.TO	S&P TSX	ONEX.TO	S&P TSX	TOU.TO
S&P TSX	GIL.TO	S&P TSX	OTEX.TO	S&P TSX	TA.TO
S&P TSX	GSY.TO	S&P TSX	OGL.TO	S&P TSX	RNW.TO
S&P TSX	GWO.TO	S&P TSX	OR.TO	S&P TSX	TCN.TO
S&P TSX	HCG.TO	S&P TSX	OSK.TO	S&P TSX	TRIL.TO
S&P TSX	HBM.TO	S&P TSX	PAAS.TO	S&P TSX	TSU.TO
S&P TSX	H.TO	S&P TSX	PXT.TO	S&P TSX	TRQ.TO
S&P TSX	IAG.TO	S&P TSX	PKI.TO	S&P TSX	VET.TO
S&P TSX	IMG.TO	S&P TSX	PPL.TO	S&P TSX	VFF.TO
S&P TSX	IGM.TO	S&P TSX	POW.TO	S&P TSX	WCN.TO
Market/Index	Yahoo ticker				
S&P TSX	WDO.TO				
S&P TSX	WFG.TO				
S&P TSX	WPRT.TO				
S&P TSX	WTE.TO				
S&P TSX	WPM.TO				
S&P TSX	WCP.TO				
S&P TSX	WPK.TO				
S&P TSX	WSP.TO				
S&P TSX	YRI.TO				
TSE	BMLT <sup>†</sup>				
TSE	BPAS <sup>†</sup>				
TSE	BSDR <sup>†</sup>				
TSE	BTEJ <sup>†</sup>				
TSE	CHML <sup>†</sup>				
TSE	FKHZ <sup>†</sup>				
TSE	FOLD <sup>†</sup>				
TSE	GDIR <sup>†</sup>				
TSE	GOLG <sup>†</sup>				
TSE	HMRZ <sup>†</sup>				
TSE	HWEB <sup>†</sup>				
TSE	IKCO <sup>†</sup>				
TSE	KSHX <sup>†</sup>				
TSE	MADN <sup>†</sup>				
TSE	MAPNA <sup>†</sup>				
TSE	MKBT <sup>†</sup>				
TSE	MOBN <sup>†</sup>				
TSE	MSMI <sup>†</sup>				
TSE	NORI <sup>†</sup>				
TSE	NOVN <sup>†</sup>				
TSE	OIMC <sup>†</sup>				
TSE	PARS <sup>†</sup>				
TSE	PASN <sup>†</sup>				
TSE	PJMZ <sup>†</sup>				
TSE	PKLJ <sup>†</sup>				
TSE	PNBA <sup>†</sup>				
TSE	PNES <sup>†</sup>				
TSE	PTAP <sup>†</sup>				
TSE	PTEH <sup>†</sup>				
TSE	SIPA <sup>†</sup>				

<sup>†</sup> Not available on Yahoo Finance.

#### 4. Results of Discussion

The effective transfer entropy was calculated, for each pair of the stocks in a given market/index, along the both directions -  $X \rightarrow Y$  and  $Y \rightarrow X$ . For each state in a given pair, the calculations were attempted over the periods, before and after the COVID-19 outbreak. The selection for the lag orders -  $k$  and  $l$  - was taken as unity, which is an appropriate choice when analyzing the financial markets [47]. The number of shuffling operations performed was set to one hundred, to ensure efficient removal of bias from the established results. Figures 1 to 26 depict the computed results for the values of the effective transfer entropy for the largest companies (by market capitalization) in the markets considered. With respect to the color interpretation of the results, a more positive number indicates more information transfer (from stock  $y$  to stock  $x$ ) and zero is the case in which no information transfer has been detected, within the considered time span. The results are provided for the both periods, before and after the virus outbreak. In order to maintain the full integrity of this paper, the whole set of computed results for all the companies considered is also being distributed in the supplementary information to this article – including the effective transfer entropy and its corresponding statistical measures (standard error, p-value).

A quick visual inspection of the results should reveal formation of new paradigms in the studied markets, after COVID-19 appearance. For major market participants (Figures 1 to 26), the newly-formed information flow pattern is seen with different levels of integrity across markets/countries. For example, the information flow between equities has risen sharply in the S&P TSX after COVID-19 (Figure 24). This rise in information flow is also the case in BSE, FTSE, JSE, Nikkei, S&P500, and S&P ASX markets. Therefore, the price action of largest equities in these markets has become more sensitive to each other, after COVID-19. The largest shift in the information flow pattern has occurred in BSE market, where the effective transfer entropy was kept minimal before the virus crisis (Figure1). In other markets, the change in information flow structure after COVID-19 has not been noticeable. This should be the case for CSI, FSE,

KSE, QSE, SASE, and TSE markets. Because the majority of the Asian markets considered herein - CSI, KSE, QSE, SASE, TSE – rely within this category, it can be further deducted that the Asian markets have been relatively insensitive to COVID-19 crisis, with the exception of Nikkei.

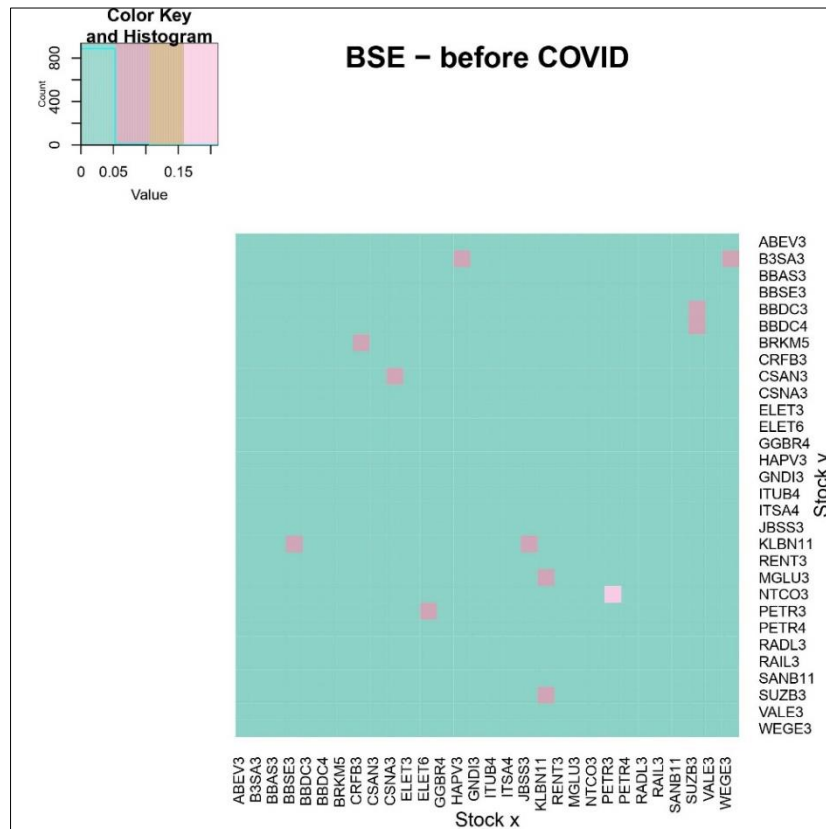


Figure 1. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the BSE market, before the COVID-19 outbreak

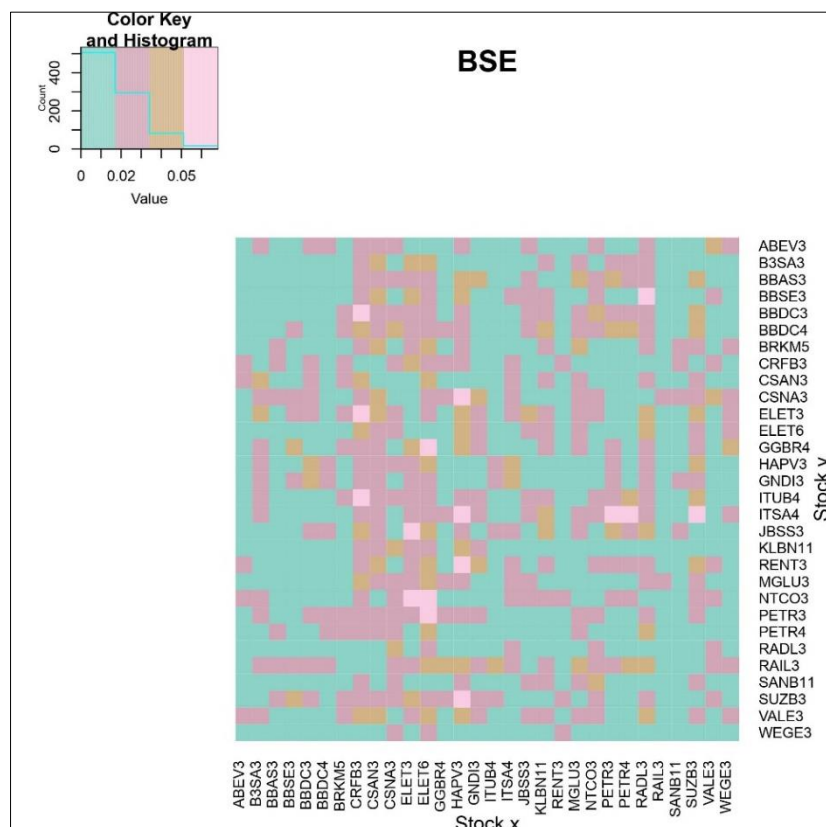
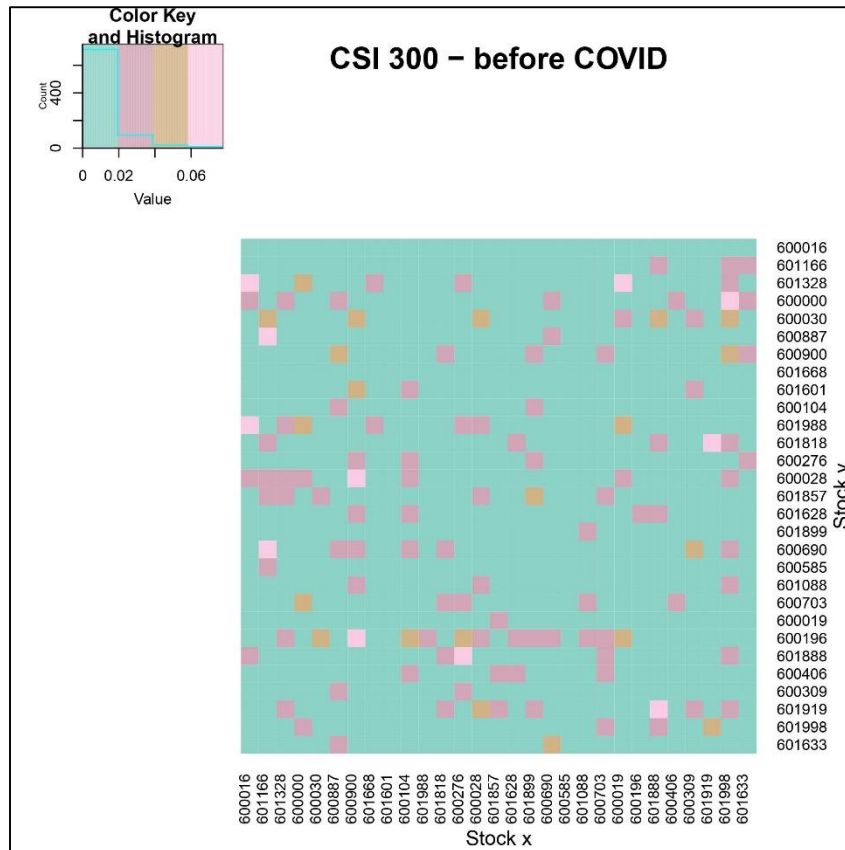
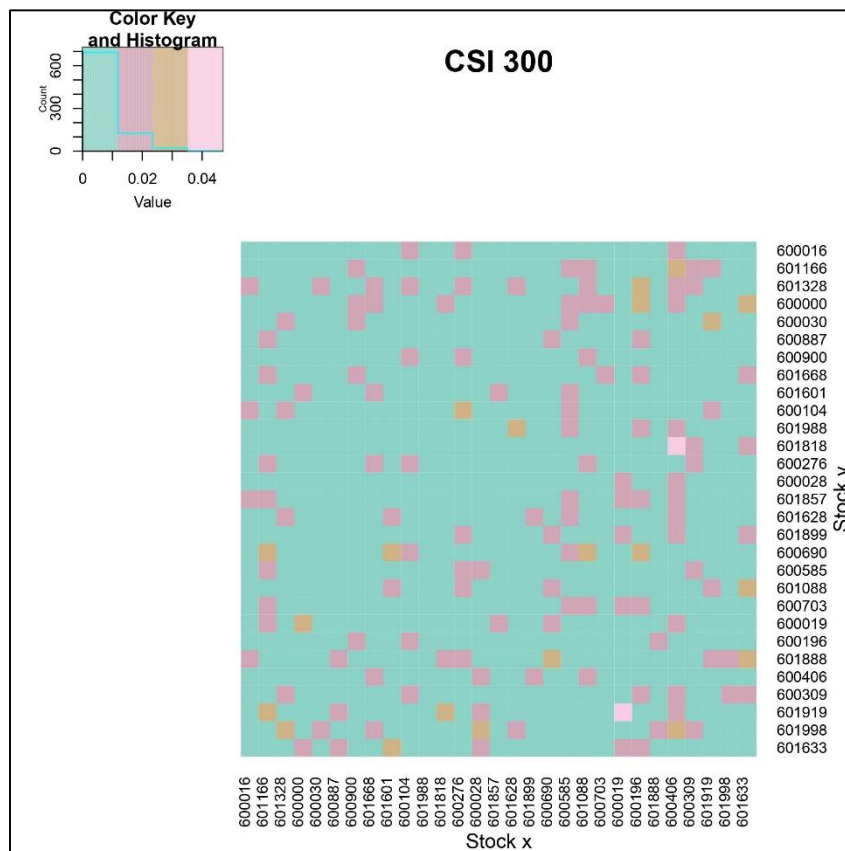


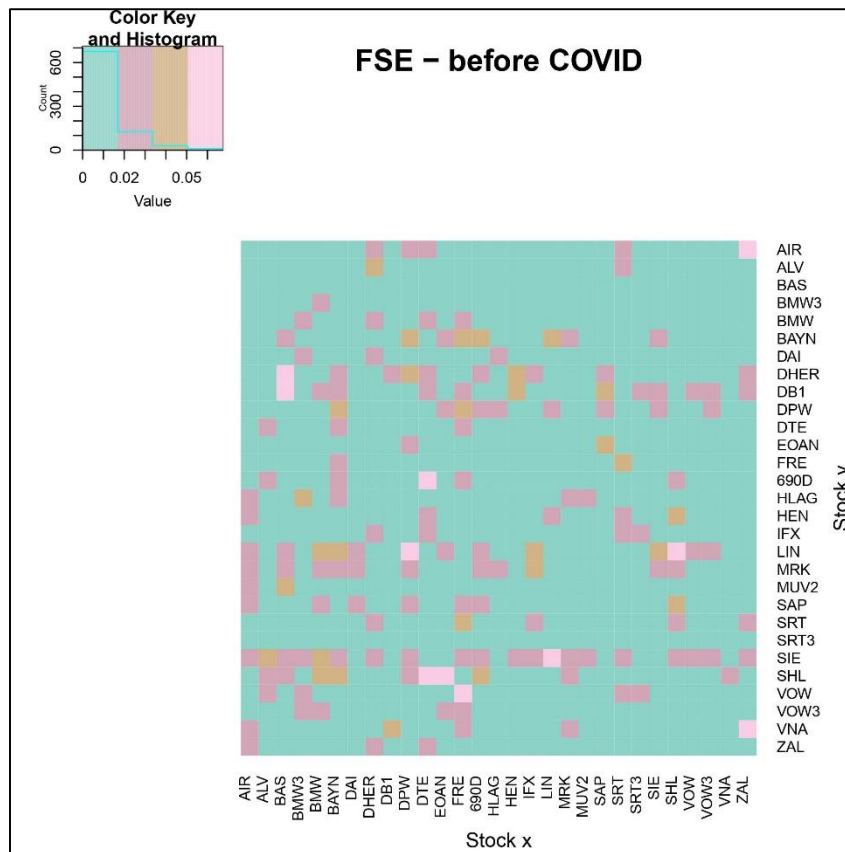
Figure 2. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the BSE market, after the COVID-19 outbreak



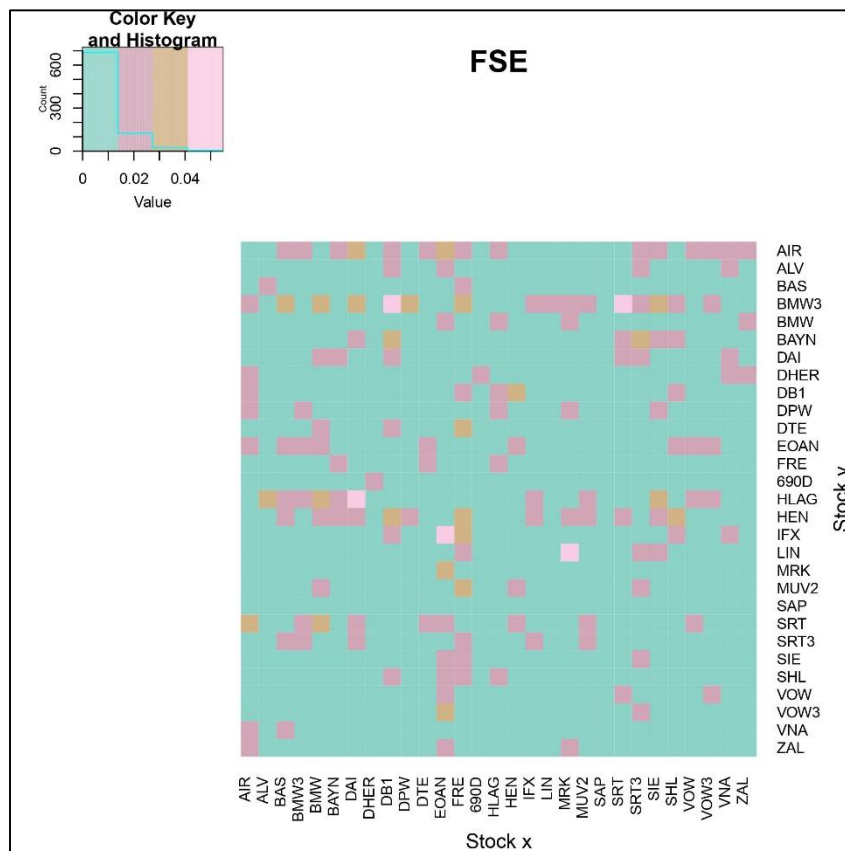
**Figure 3. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the CSI market, before the COVID-19 outbreak**



**Figure 4. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the CSI market, after the COVID-19 outbreak**

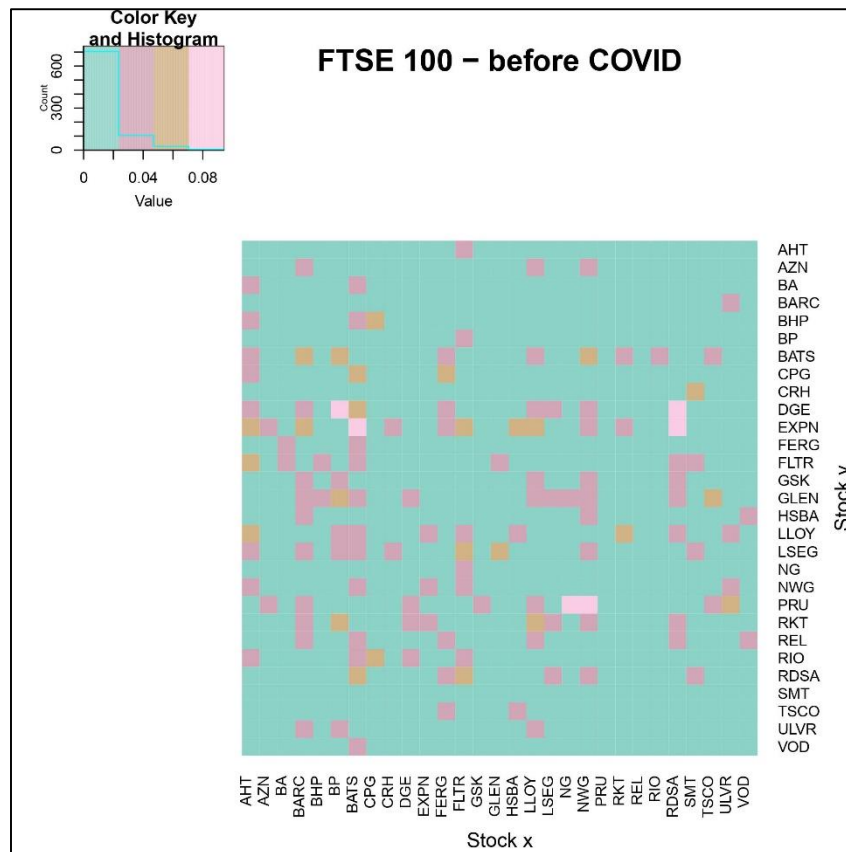


**Figure 5. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the FSE market, before the COVID-19 outbreak**

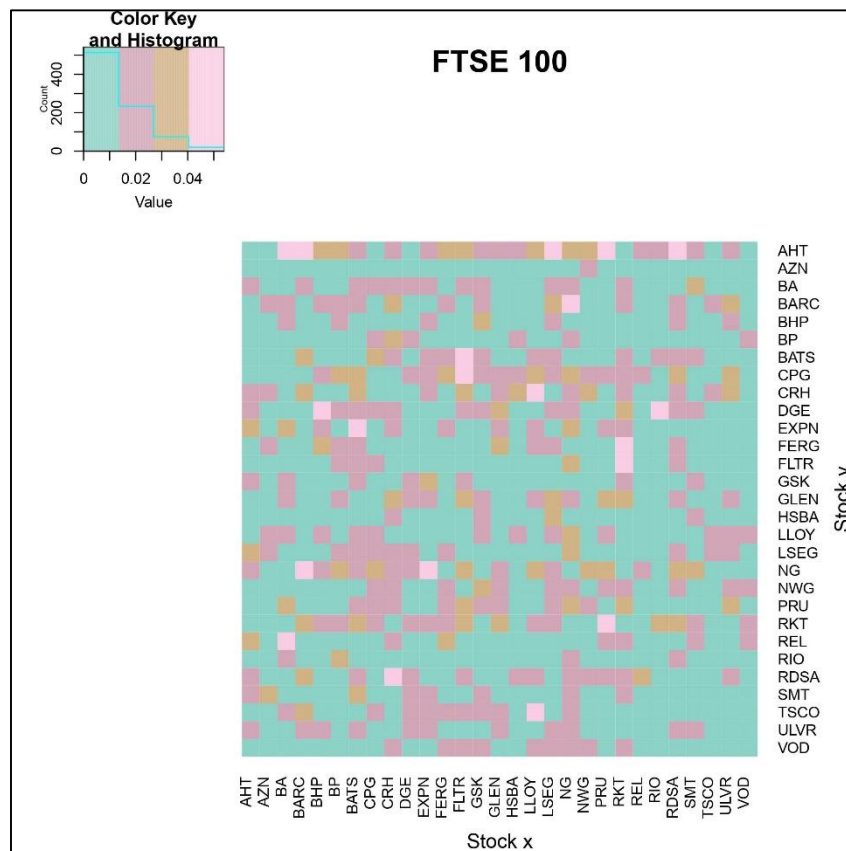


**Figure 6. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the FSE market, after the COVID-19 outbreak**

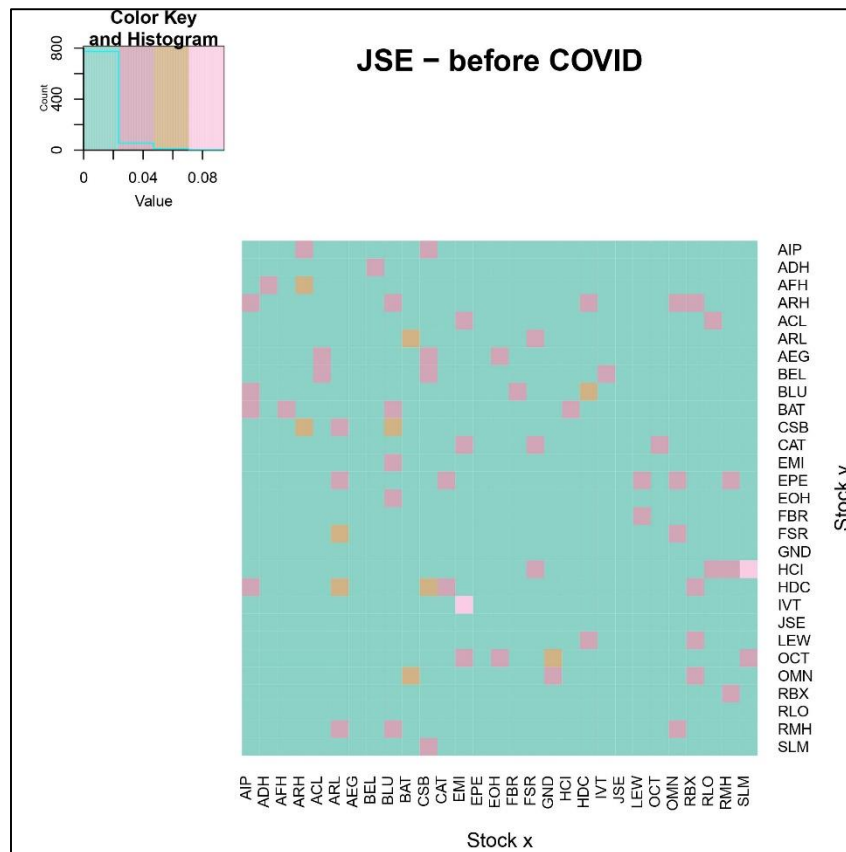




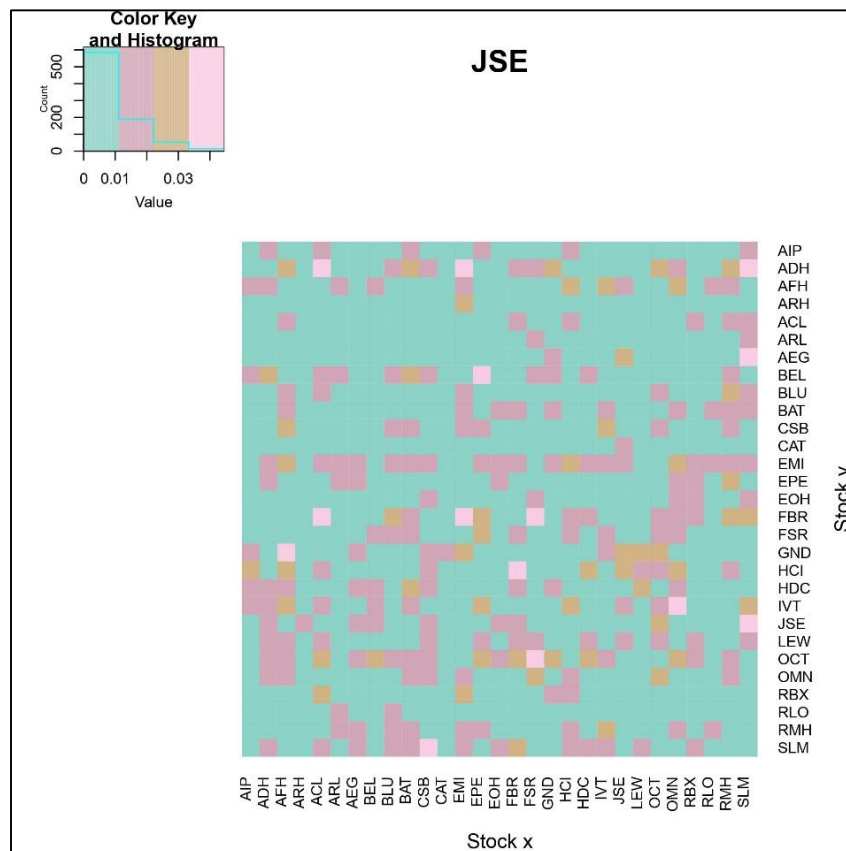
**Figure 7. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the FTSE market, before the COVID-19 outbreak**



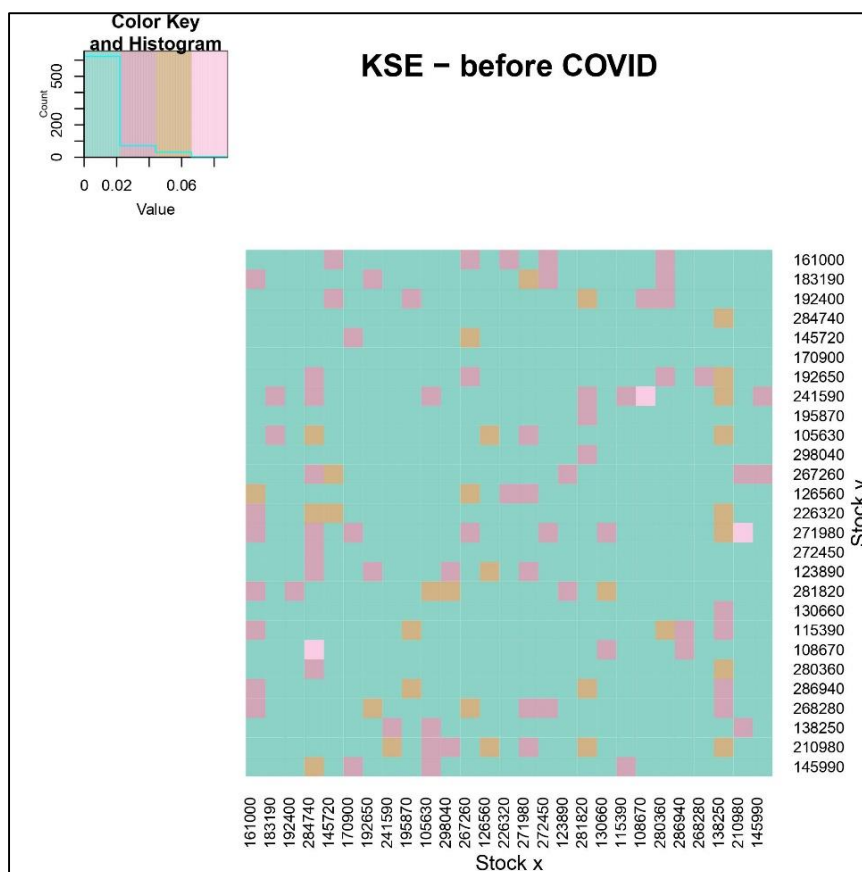
**Figure 8. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the FTSE market, after the COVID-19 outbreak**



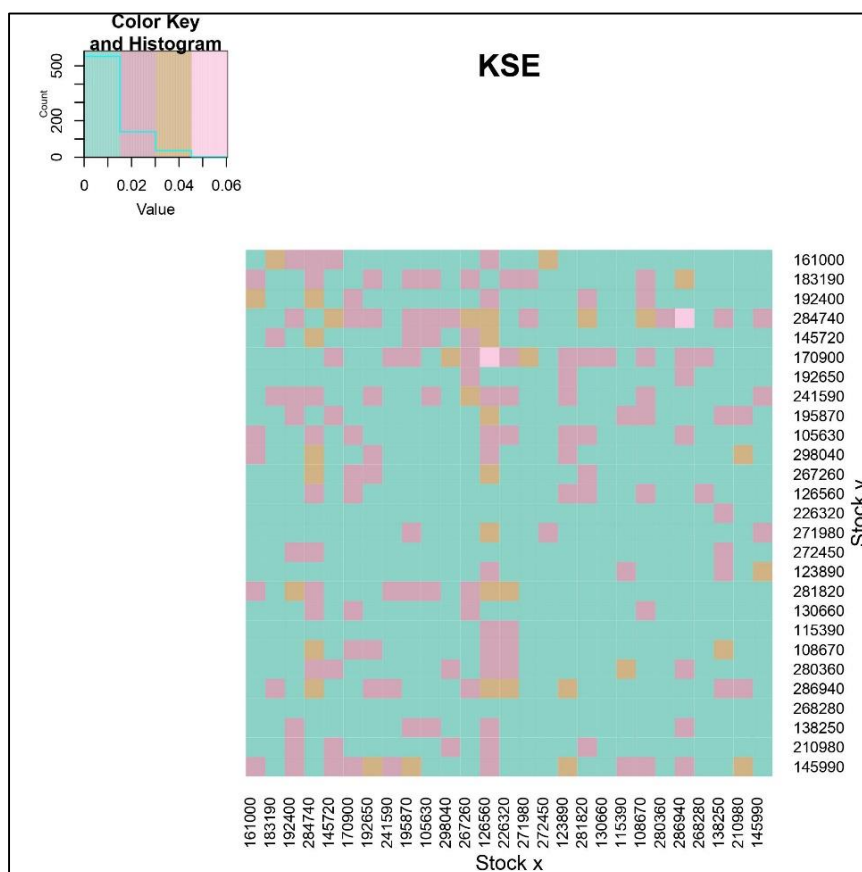
**Figure 9. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the JSE market, before the COVID-19 outbreak**



**Figure 10. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the JSE market, after the COVID-19 outbreak**



**Figure 11.** The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the KSE market, before the COVID-19 outbreak



**Figure 12.** The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the KSE market, after the COVID-19 outbreak

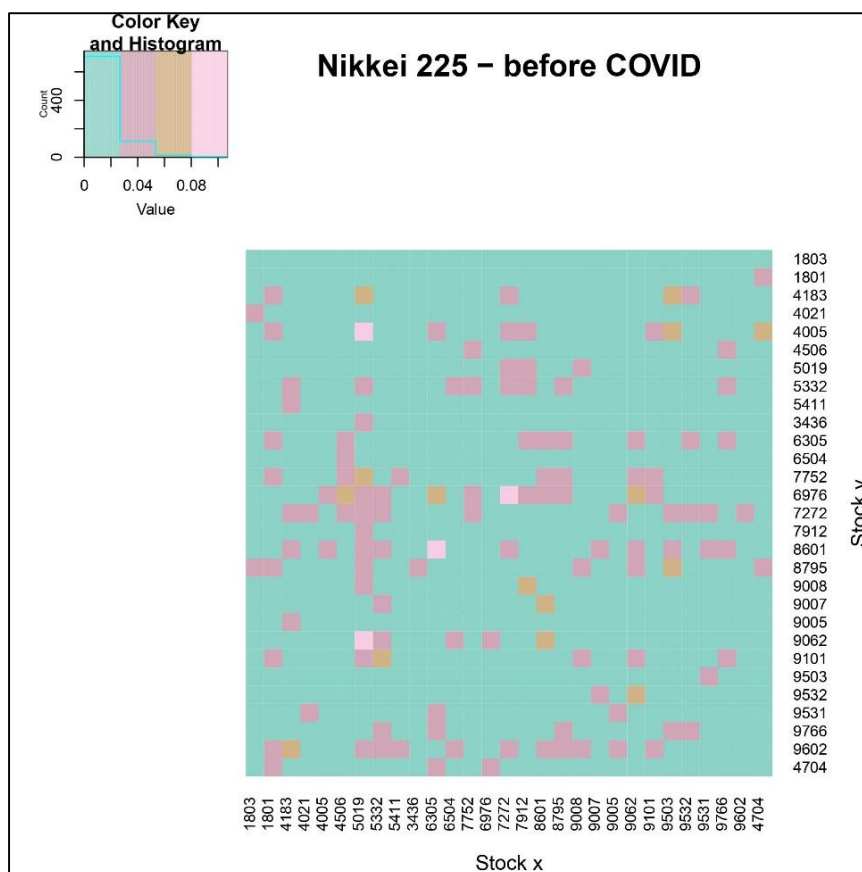


Figure 13. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the Nikkei market, before the COVID-19 outbreak

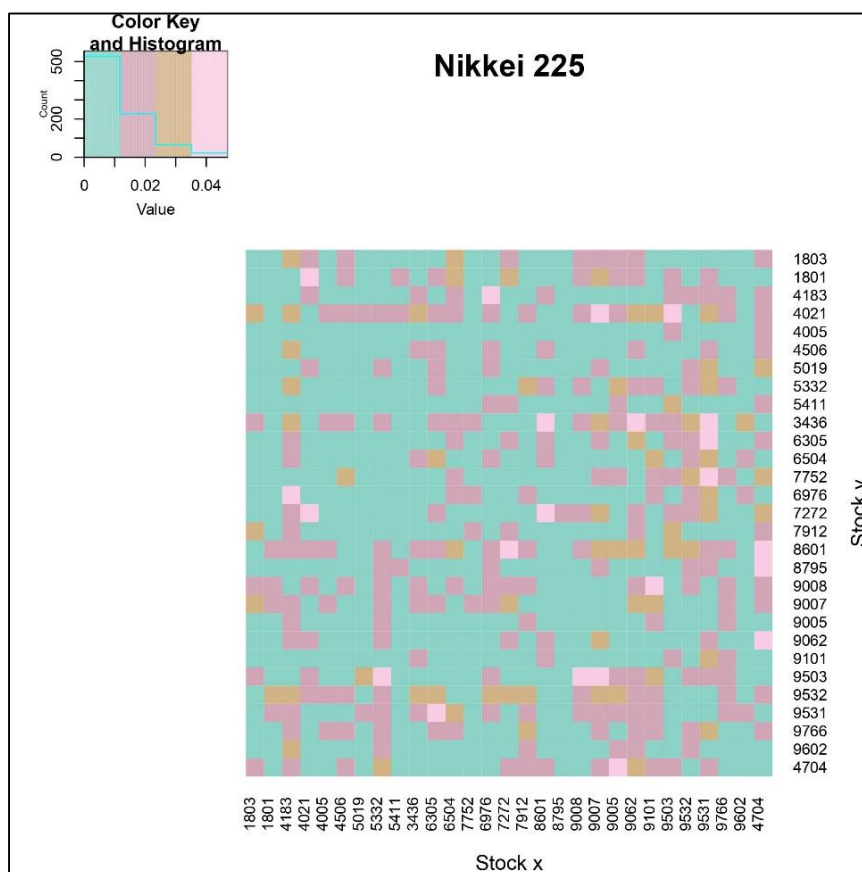


Figure 14. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the Nikkei market, after the COVID-19 outbreak

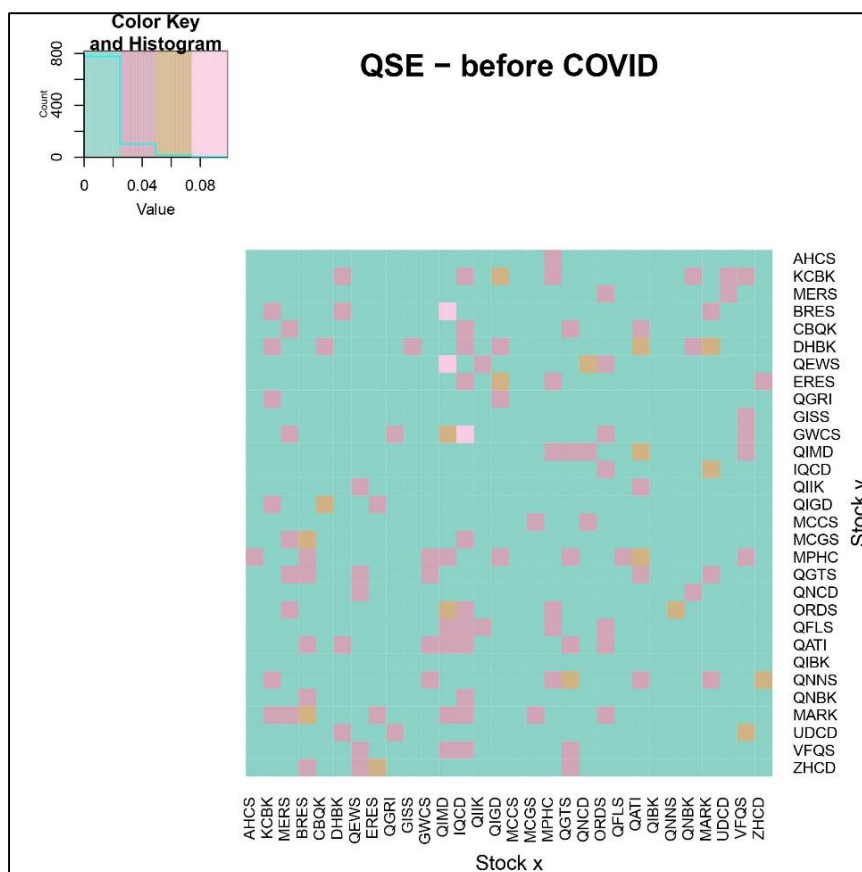


Figure 15. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the QSE market, before the COVID-19 outbreak

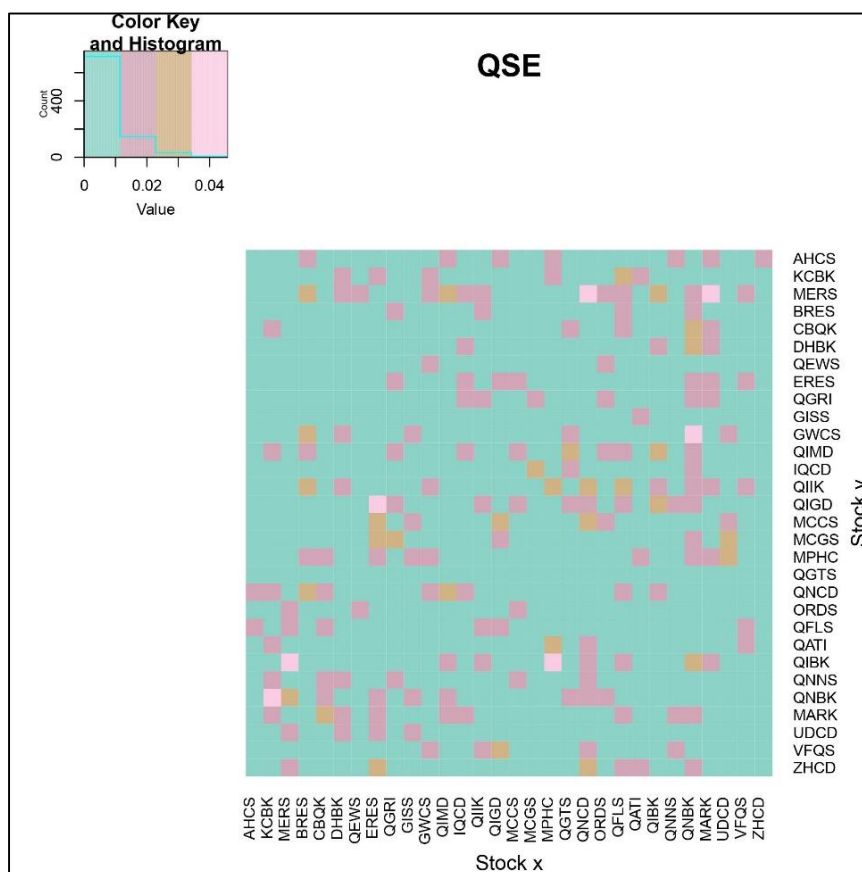
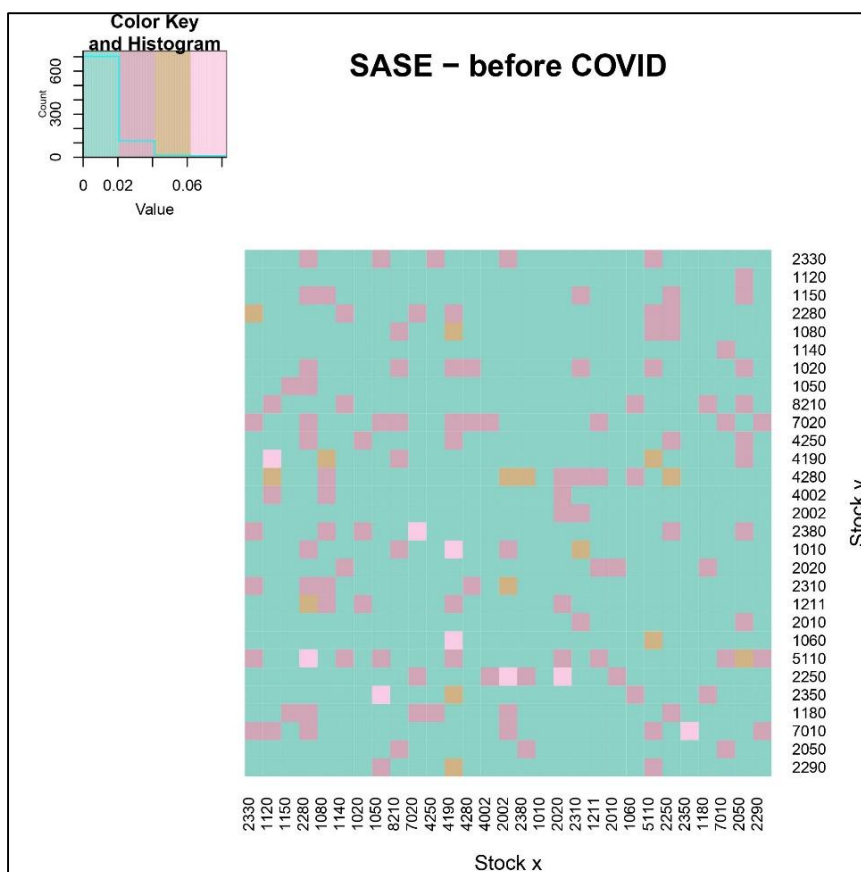
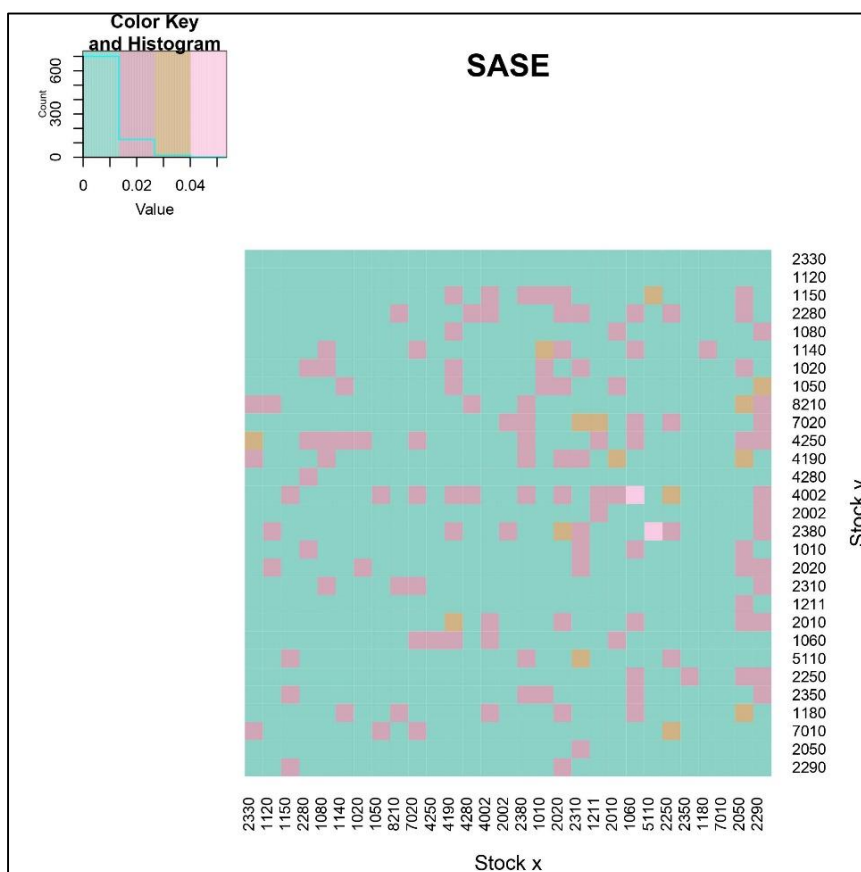


Figure 16. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the QSE market, after the COVID-19 outbreak

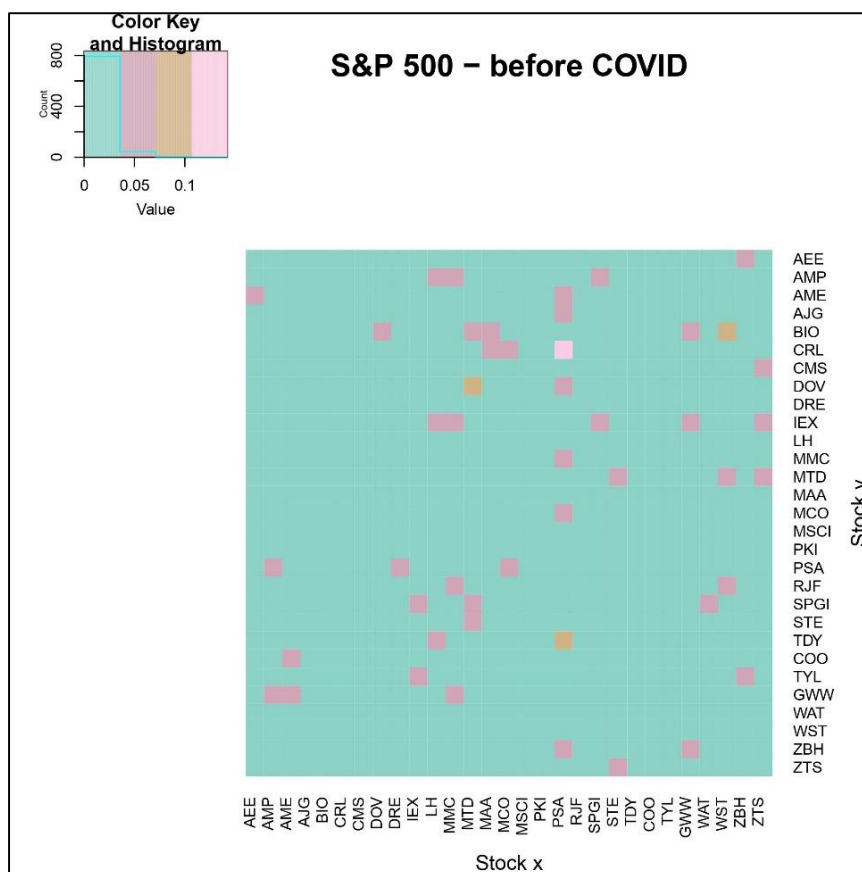




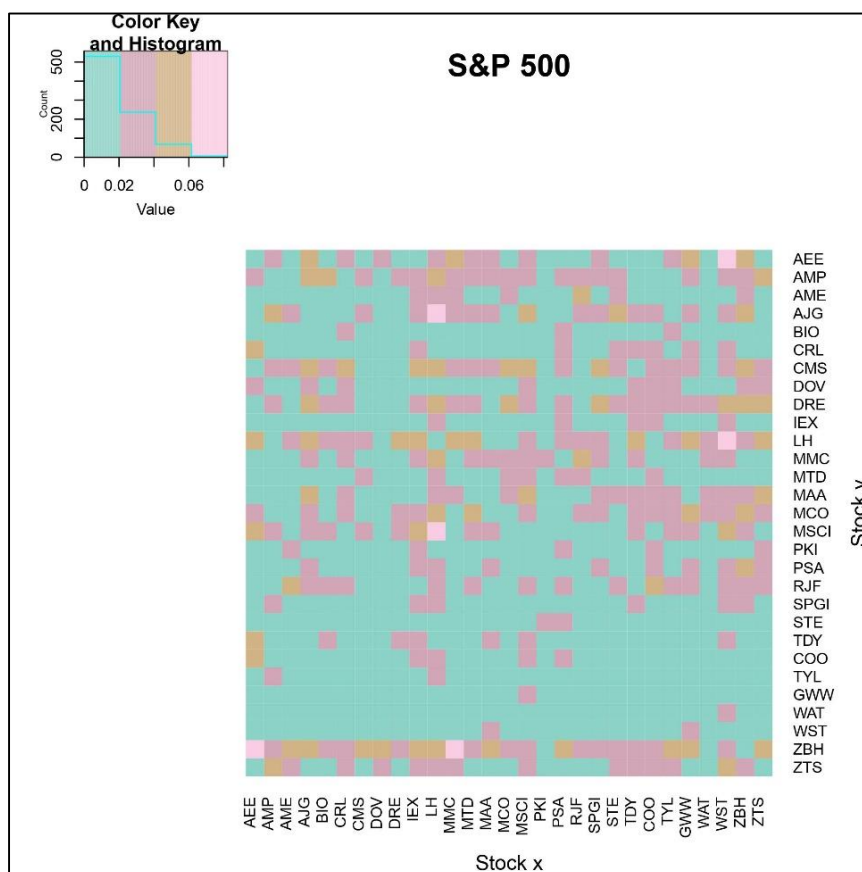
**Figure 17. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the SASE market, before the COVID-19 outbreak**



**Figure 18. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the SASE market, after the COVID-19 outbreak**



**Figure 19.** The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the S&P500 market, before the COVID-19 outbreak



**Figure 20.** The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the S&P500 market, after the COVID-19 outbreak

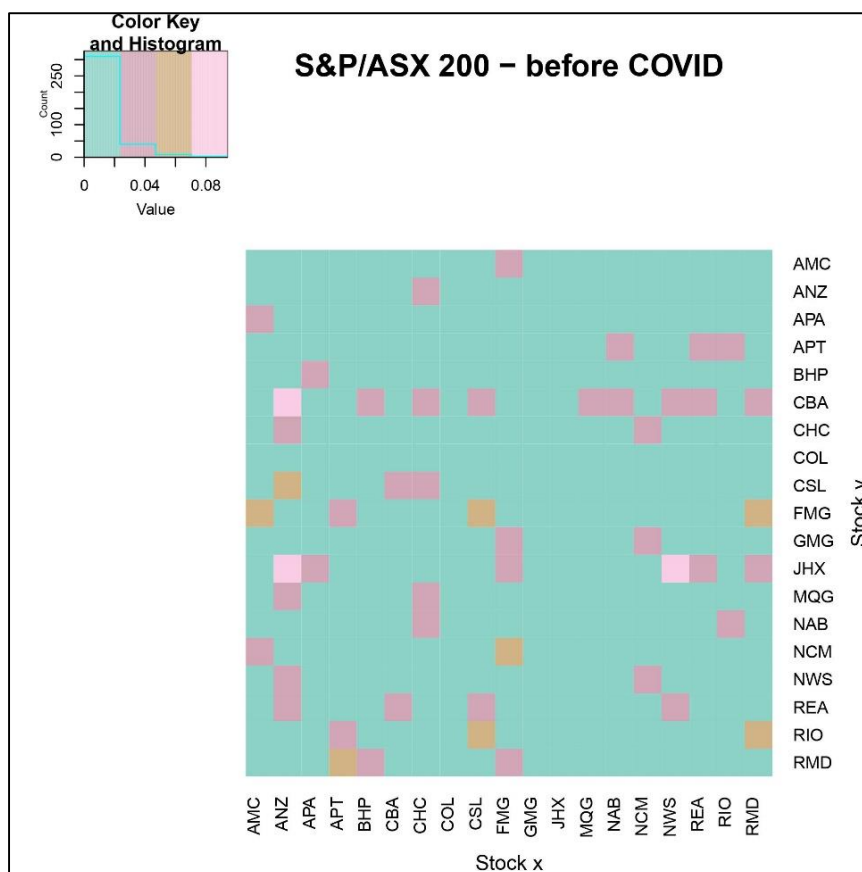


Figure 21. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the S&P ASX market, before the COVID-19 outbreak

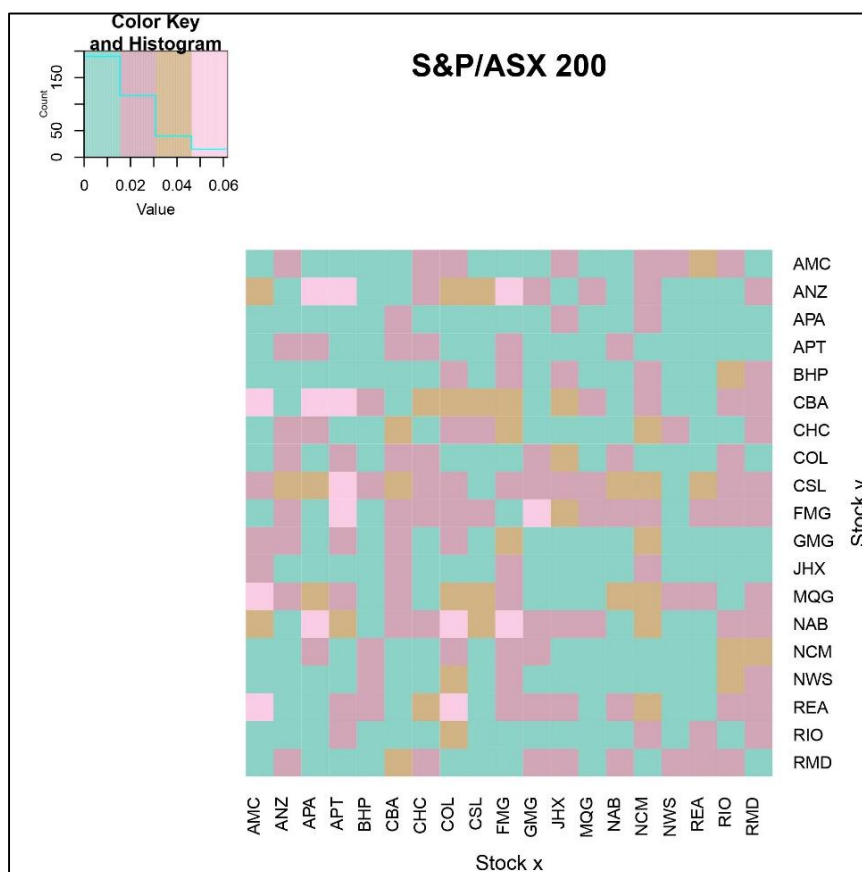


Figure 22. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the S&P ASX market, after the COVID-19 outbreak



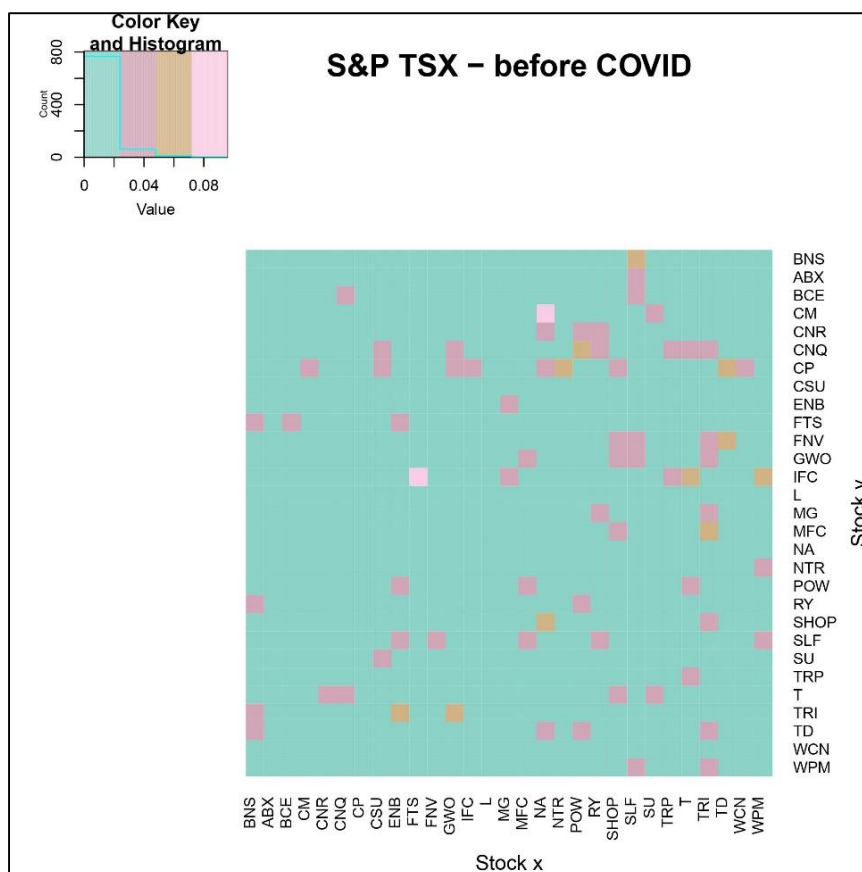


Figure 23. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the S&P TSX market, before the COVID-19 outbreak

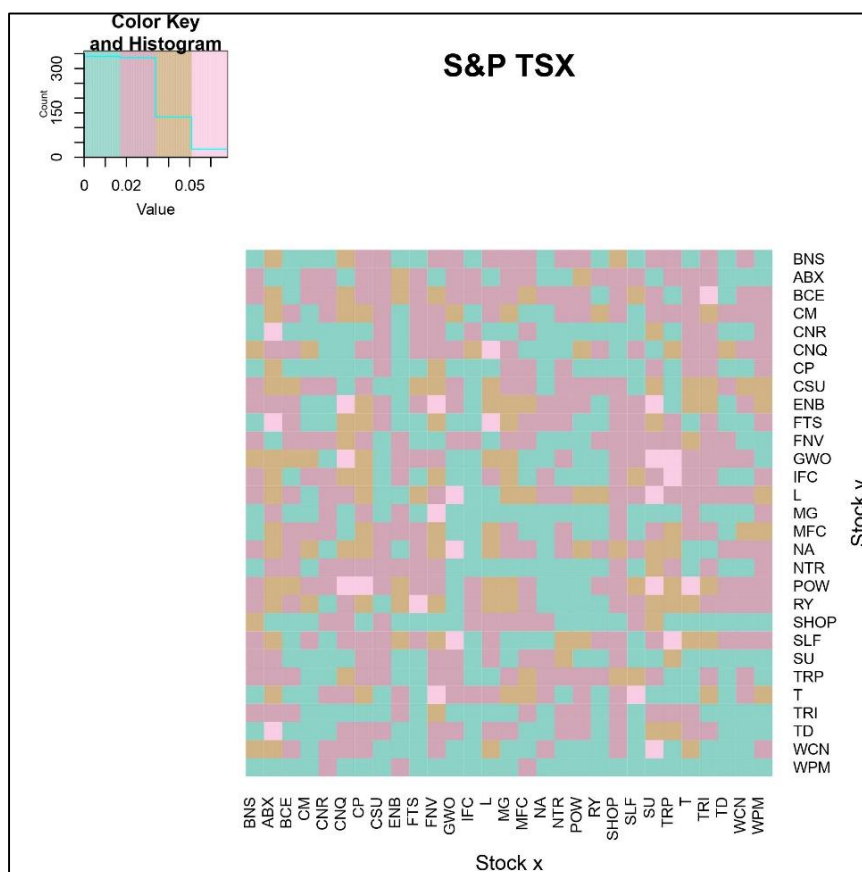
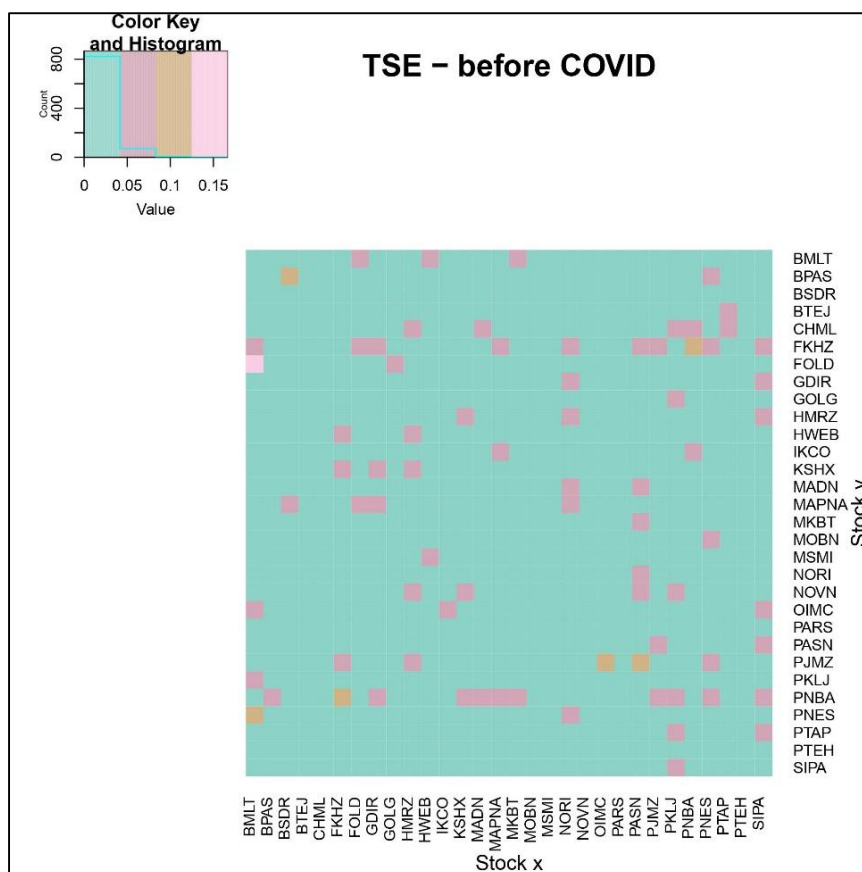
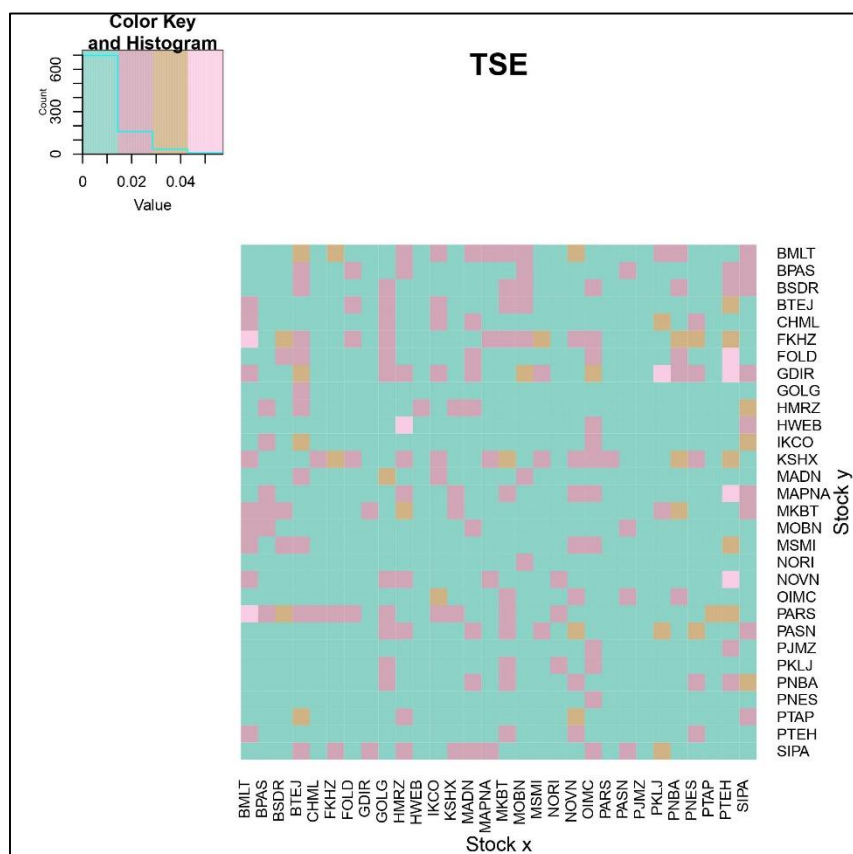


Figure 24. The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the S&P SX market, after the COVID-19 outbreak



**Figure 25.** The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the TSE market, before the COVID-19 outbreak



**Figure 26.** The information flow (effective transfer entropy) from stock y to stock x, for the top companies (by market capitalization) in the TSE market, after the COVID-19 outbreak

As part of our analysis in the present paper, we have also studied the change in market functionality after COVID-19, on a sector level. For a selected sector in a given market, the (average) information inflow/outflow was determined by summing the effective transfer entropy inflow/outflow of the stocks in that sector and dividing the result by the number of stocks involved. The net information outflow,  $\Delta F$ , was taken as the difference between the average information outflow and the average information inflow. A sector is then interpreted as being an information transmitter (receiver) if the net information outflow is positive (negative). Tables 2 to 15 lists the computed net information outflow for the sectors within the markets considered. For the TSE market, only the top 30 companies by market capitalization were studied. Therefore, the listed sectors in Tables 14 to 15 merely correspond to the sectors of the selected TSE stocks.

**Table 2. The net information outflow for the sectors in BSE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Consumer Defensive	0.0011	-0.0186
Industrials	0.0088	0.0069
Financial Services	0.0178	0.0101
Real Estate	0.0051	-0.0217
Basic Materials	0.0172	0.0310
Consumer	-0.0047	0.0135
Utilities	-0.0274	0.0202
Consumer Cyclical	-0.0258	0.0109
Technology	0.0038	-0.0117
Energy	0.0118	-0.0129
Healthcare	-0.0080	-0.0280

**Table 3. The net information outflow for the sectors in CSI market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Financial Services	0.0640	0.0371
Financial	0.0147	-0.0018
Consumer	0.0045	-0.0118
Consumer Defensive	0.0028	0.0010
Utilities	-0.0351	-0.0087
Industrials	-0.0517	-0.0133
Consumer Cyclical	-0.0031	0.0085
Real Estate	0.0090	0.0012
Healthcare	0.0440	-0.0082
Energy	-0.0159	0.0049
Communication Services	-0.0049	-0.0013
Basic Materials	-0.0337	-0.0029
Technology	0.0043	-0.0024
Communication	0.0007	-0.0032

**Table 4. The net information outflow for the sectors in FSE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Communication	-0.0077	-0.0019
Healthcare	-0.0163	-0.0044
Industrials	0.0269	0.0356
Financial	0.0125	0.0019
Real estate	-0.0036	0.0029
Consumer	0.0007	0.0196
Services	-0.0021	0.0022
Technology	-0.0403	-0.0356
Financial Services	0.0030	-0.0036
Real Estate	0.0021	-0.0053
Utilities	0.0120	-0.0201
Energy	0.0017	0.0056
Consumer Defensive	-0.0003	0.0038
Basic Materials	0.0077	-0.0027
Consumer Cyclical	0.0036	0.0019

**Table 5. The net information outflow for the sectors in FTSE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Financial	0.0160	0.0149
Financial Services	-0.0279	0.0123
Basic Materials	0.0351	-0.0178
Industrials	0.0334	0.0119
Consumer Defensive	-0.0202	-0.0335
Healthcare	0.0127	-0.0089
Communication Services	-0.0089	0.0096
Technology	0.0042	0.0046
Consumer	0.0051	0.0167
Consumer Cyclical	-0.0250	0.0184
Energy	-0.0025	-0.0116
Real Estate	-0.0066	-0.0022
Communication	0.0064	0.0010
Real	-0.0087	-0.0005
Utilities	-0.0131	-0.0149

**Table 6. The net information outflow for the sectors in JSE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Real Estate	-0.0033	0.0050
Industrials	0.0049	-0.0010
Healthcare	0.0047	-0.0048
Consumer Defensive	-0.0059	0.0043
Basic Materials	0.0094	-0.0035
Consumer Cyclical	-0.0014	0.0051
Financial Services	0.0075	-0.0120
Communication Services	-0.0035	0.0019
Technology	-0.0043	0.0000
Energy	-0.0089	0.0054
Financial	0.0010	-0.0005

**Table 7. The net information outflow for the sectors in KSE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Financial Services	0.0113	-0.0139
Real Estate	-0.0315	0.0015
Industrials	0.0510	-0.0112
Basic Materials	0.0209	0.0072
Technology	-0.0222	0.0068
Consumer Defensive	0.0031	0.0213
Communication Services	-0.0195	-0.0211
Consumer Cyclical	0.0042	0.0129
Healthcare	-0.0284	-0.0017
Utilities	0.0053	-0.0014
Energy	0.0049	0.0010
Consumer	0.0008	-0.0013

**Table 8. The net information outflow for the sectors in Nikkei market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Consumer Defensive	-0.0432	-0.0144
Energy	-0.0287	0.0107
Industrials	0.0822	-0.0453
Consumer Cyclical	0.0021	0.0338
Consumer	0.0115	0.0013
Basic Materials	-0.0128	-0.0412
Healthcare	0.0203	-0.0452
Technology	-0.0482	0.0153
Financial Services	0.0201	0.0754
Real Estate	0.0019	0.0134
Communication Services	0.0082	-0.0040
Utilities	-0.0135	0.0000

**Table 9. The net information outflow for the sectors in QSE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Industrials	0.0044	0.0050
Financial Services	0.0115	-0.0114
Financial	0.0087	0.0006
Consumer	-0.0058	0.0055
Real Estate	-0.0134	0.0111
Communication Services	-0.0075	0.0020
Utilities	0.0010	0.0013
Energy	0.0078	-0.0024
Basic Materials	-0.0120	-0.0017
Technology	-0.0004	0.0023
Healthcare	0.0025	0.0037
Consumer Defensive	0.0029	0.0056

**Table 10. The net information outflow for the sectors in SASE market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Consumer Cyclical	-0.0041	-0.0063
Consumer	-0.0347	0.0043
Basic Materials	-0.0322	0.0041
Financial Services	0.0257	0.0153
Industrials	0.0125	0.0129
Consumer Defensive	0.0103	-0.0251
Healthcare	-0.0071	-0.0148
Technology	0.0034	0.0032
Real Estate	0.0069	0.0178
Financial	0.0064	-0.0044
Utilities	0.0025	0.0014
Energy	0.0037	-0.0022
Communication Services	0.0135	-0.0075

**Table 11. The net information outflow for the sectors in S&P ASX market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Basic Materials	0.0223	-0.0384
Real Estate	-0.0051	0.0071
Utilities	-0.0085	-0.0107
Industrials	0.0000	0.0380
Energy	0.0032	-0.0142
Communication Services	-0.0171	0.0234
Technology	0.0025	-0.0439
Consumer	-0.0053	-0.0117
Financial Services	-0.0015	0.0673
Healthcare	-0.0039	-0.0004
Financial	-0.0013	0.0085
Consumer Defensive	0.0023	-0.0309
Consumer Cyclical	0.0072	-0.0041
Communication	0.0050	0.0100

**Table 12. The net information outflow for the sectors in S&P TSX market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Industrials	-0.0075	-0.0375
Basic Materials	0.0491	-0.1198
Utilities	-0.0130	0.0469
Real Estate	0.0033	-0.0058
Energy	0.0128	0.0388
Consumer Cyclical	-0.0117	0.0026
Healthcare	-0.0237	0.0019
Financial	-0.0063	0.0429
Financial Services	0.0065	0.0517
Communication Services	-0.0001	0.0094
Technology	0.0021	-0.0088
Consumer	-0.0034	-0.0452
Consumer Defensive	-0.0079	0.0227

**Table 13. The net information outflow for the sectors in S&P500 market, before and after COVID-19 outbreak**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Industrials	0.0253	-0.0264
Healthcare	-0.0523	-0.1065
Technology	0.1219	-0.1095
Communication	-0.0427	-0.0493
Consumer Defensive	0.0067	-0.0128
Consumer	0.0113	-0.1580
Utilities	-0.1425	0.1679
Financial	0.0339	0.2045
Basic Materials	0.0377	-0.0140
Real Estate	-0.0484	0.1100
Financial Services	0.0115	0.0464
Energy	0.0368	-0.0618
Consumer Cyclical	-0.0099	0.0123
Communication Services	0.0106	-0.0026

**Table 14. The net information outflow for the sectors in TSE market, before and after COVID-19 outbreak – evaluated through the symbolic coding scheme of Equation 8**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Banking	-0.0006	-0.0067
Basic Materials	0.0351	-0.0013
Steel	0.0177	0.0134
Mining	-0.0161	0.0057
Telecommunications	-0.0067	-0.0067
Information Technology	0.0038	0.0030
Auto	-0.0166	-0.0037
Marine transportation	-0.0025	0.0089
Engineering	0.0080	-0.0019
Electricity	0.0059	-0.0042
Energy	0.0025	-0.0069
Chemicals	-0.0305	0.0006

**Table 15. The net information outflow for the sectors in TSE market, before and after COVID-19 outbreak – evaluated through the symbolic coding scheme of Equation 9**

Sector	$\Delta F_{before}$	$\Delta F_{after}$
Banking	-0.3530	0.3549
Basic Materials	0.0172	0.1251
Steel	-0.2723	0.3355
Mining	0.2811	0.1992
Telecommunications	-0.2774	-0.2168
Information Technology	0.0659	-0.6752
Auto	0.0087	-0.0420
Marine transportation	-0.3116	-0.1363
Engineering	0.0937	-0.0047
Electricity	0.0621	-0.1046
Energy	0.4894	0.1138
Chemicals	0.1960	0.0510

In general, the results indicate a large number of shifts to have occurred in the status of sectors – in terms of being a receiver or transmitter of information - after COVID-19 in the studied markets. This change in sector functionality – shifting from an information transmitter to receiver, or vice versa– can provide valuable information on the general price action.

Based on our results, the highest number of shifts in sector functionality has been encountered in JSE, S&P500, S&P ASX, and S&P TSX markets. In South Africa, for instance, the sector functionality of over 90% of JSE sectors has altered after COVID-19 – suggesting a complete re-shaping of its underlying information transmission network. In other words, the sectors which used to influence others, now tend to be influenced, and the reverse exists. The fraction of sectors changing functionality has also been high in the Australian and North American markets – 73% (S&P ASX), 71% (S&P TSX), and 68% (S&P500). The European markets have been more stable, in this regards. For the markets in Germany and the U.K., less than half of the sectors have changed functionality after COVID-19 – 43% (FSE), and 37% (FTSE). Since FTSE was earlier found with a large change in its information flow pattern (Figure 8), the fairly low number of changes in the status of its sectors should mean that the conceived post-COVID changes are mainly caused by an alteration in the intensity (and not the direction) of information flow between equities, in that market. For the market in Brazil, the situation resembles its North American counterparts – 58% (BSE). The fraction of sectors changing functionality has been at/below the middle for the markets in Iran, Japan, Qatar, Saudi Arabia and South Korea – 50% (TSE), 50% (Nikkei), 42% (QSE), 35% (SASE), 46% (KSE). For China, this fraction is slightly above the average - 53% (CSI). Following the same analogy put forth for the FTSE market in the above, it can be concluded that the changes in CSI market after COVID-19, are mainly due to changes in the direction of information flow between equities, in that market. In other words, the intensity of effective transfer entropy has remained mostly unchanged after virus crisis, in the CSI market (Figure 4).

With respect to the performance of industries after COVID-19, the response of the markets are varied. The financial services, real states, utilities, and consumer cyclical sectors are generally found in the transmitter status in these markets. The financial services sector, for example, has maintained its influencing role after COVID-19 outbreak, in 9 out of 13 markets studied – with the exception of FSE, KSE, QSE and TSE. The healthcare sector is found as being an information

receiver in the majority of markets – except QSE, and S&P TSX – after COVID-19. For some sectors – such as the Industrials – the situation has been mixed; as it has functioned both as an information transmitter and an information receiver, in relatively equal number of markets studied, after COVID-19. The real estate sector seems to be the most influencing sector in some Asian markets; such as Qatar and Saudi Arabia, which has presumably received the least impacts from COVID-19.

In the period after COVID-19 outbreak, the pattern of markets has posed different sectors as their leading (most-influencing) ones. Based on our results, this updated list is not unanimous. Tables 16 to 19 list the names of the main information transmitter (receiver) sectors, for pre/after-COVID periods, in the markets studied. The names of the sectors is based on the names, which were attributed by the Yahoo Finance. The tables includes two entries for the TSE market, the second of which relates to the case when the effective transfer entropy is evaluated through the detailed encoding system - Equation 9.

**Table 16. The main information transmitter sectors, before COVID-19**

Market/Index	Sector
BSE	Financial Services
CSI	Financial Services
FSE	Industrials
FTSE	Basic Materials
JSE	Basic Materials
KSE	Industrials
Nikkei	Industrials
QSE	Financial Services
SASE	Industrials
S&P ASX	Basic Materials
S&P TSX	Basic Materials
S&P500	Technology
TSE	Banking
TSE*	Energy

\* Evaluated through Equation 9

**Table 17. The main information receiver sectors, before COVID-19**

Market/Index	Sector
BSE	Consumer Cyclical
CSI	Industrials
FSE	Technology
FTSE	Financial Services
JSE	Energy
KSE	Real Estate
Nikkei	Technology
QSE	Basic Materials
SASE	Consumer
S&P ASX	Communication Services
S&P TSX	Healthcare
S&P500	Utilities
TSE	Chemicals
TSE*	Banking

\* Evaluated through Equation 9



**Table 18. The main information transmitter sectors, after COVID-19**

Market/Index	Sector
BSE	Basic Materials
CSI	Financial Services
FSE	Industrials
FTSE	Consumer Cyclical
JSE	Energy
KSE	Consumer Defensive
Nikkei	Financial Services
QSE	Real Estate
SASE	Real Estate
S&P ASX	Financial Services
S&P TSX	Financial Services
S&P500	Financial
TSE	Steel
TSE*	Banking

\* Evaluated through Equation 9

**Table 19. The main information receiver sectors, after COVID-19**

Market/Index	Sector
BSE	Healthcare
CSI	Industrials
FSE	Technology
FTSE	Consumer Defensive
JSE	Financial Services
KSE	Communication Services
Nikkei	Industrials
QSE	Financial Services
SASE	Consumer Defensive
S&P ASX	Technology
S&P TSX	Basic Materials
S&P500	Consumer
TSE	Energy
TSE*	Information Technology

\* Evaluated through Equation 9

The basic materials, communications, energy, and utilities sectors seem to have an intermediate position in the information flow diagram in most of the markets studied after COVID-19. Based on our results, the German market – FSE—seems to be the only market where no change has occurred as for its main information transmitter/receiver sectors after the COVID-19 outbreak. As mentioned earlier, the results presented this far have been obtained using the prevalent encoding system—based on 5% and 95% quantiles of data—for its evaluation of probability (Equation 8). The sensitivity of results towards this choice was investigated for the case of the TSE market by evaluating the effective transfer entropy through a more detailed encoding system (Equation 9). As one may notice, the results tend to be sensitive to this choice, as the computed effective transfer entropy values and the resultant sector behavior might differ from the earlier choice. Since the bulk of literature adopts a similar encoding system (Equation 8) in their analysis, the results presented herein should form the basis for later comparison. Nevertheless, further investigations are suggested to analyze the issue on the premise of a more detailed encoding system.

## 5. Conclusion

The paradigm of information flow has undergone changes since COVID-19's appearance in several global equity markets, albeit at different levels. The analysis of this interaction pattern for the largest market participants (by market capitalization) shows that the most changes have occurred in the BSE, Nikkei, S&P500, S&P ASX, and S&P TSX markets. In this respect, the Asian markets—CSI, KSE, QSE, SASE, TSE—have been more robust to the COVID-19 issue, exhibiting few changes in their information transfer paradigm. On the sector level, the COVID-19 pandemic has been concurrent with drastic changes in the functionality of sectors in the studied markets. The fraction of sectors changing functionality has exceeded 70% in the JSE, S&P500, S&P ASX, and S&P TSX markets—indicating that the influencing role of the majority of sectors in these markets has reversed completely since COVID-19's appearance. The financial services sector has maintained its influential role in 9 out of 13 markets studied after the COVID-19 pandemic. The main information transmitter and receiver sectors have changed since COVID-19 in the studied markets, except for the FSE market, where they have remained unchanged. The results of the effective transfer entropy are found to be sensitive to the choice of the encoding system for its probability evaluation, necessitating further studies in that respect. The findings of this paper – distributing the information flow of nearly 2200 companies worldwide – should be valuable for market participants in devising recovery action plans for vulnerable sectors or efficiently managing portfolio diversifications. In essence, our results indicate substantial changes to global equity markets—with respect to the price action between equities and their resultant sector functionalities—which have been concurrent with the outbreak of the COVID-19 virus.

## 6. Declarations

### 6.1. Author Contributions

All authors have equally contributed towards Conceptualization, methodology, formal analysis, investigation, resources, writing—original draft preparation, writing—review and editing, visualization. All authors have read and agreed to the published version of the manuscript.

### 6.2. Data Availability Statement

The data presented in this study are available in the article.

### 6.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

### 6.4. Declaration of Competing Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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