Analyzing Impact of COVID-19 Pandemic on Global Stock Prices

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***Abstract*— The spread of COVID-19 is making a serious impact on the world economy. As policies to maintain economic activities have been implemented in a timely manner, many stock markets have regained their stock prices to pre-corona levels, although there are still strong opinions that the prices fail to reflect the real economy. This paper describes results of statistical analyses of daily historical data concerning Dow Jones Industrial Average (DJIA), Nasdaq Composite Index (NASDAQ), France Stock Index (CAC), German Stock Index (DAX), Shanghai Composite Index (SSEC) and Nikkei Stock Average (Nikkei). In general, these stock prices plunged for approximately 20 days before the trading day that marked the lowest price, and increased for the next 25 days. Reflecting the fact that the world economies are tightly related to each other, it is confirmed that stock price fluctuations under study generally show the same trend. We propose a technical indicator defined by the difference between a stock price and moving average. The results of our experiments show that the indicator predicts short-term trends with a slight time lag.**

Keywords*— *COVID-19 infection; Technical indicator; Global market comparison; Candlestick chart.

I. INTRODUCTION

More than a year has passed since the first Covid-19 infection was confirmed. But the spread of coronavirus is still continuing and the number of daily infections remains high. The spread of COVID-19 is forecasted to have a significant adverse impact on the global economy. While the global real Gross Domestic Product (GDP) grew by 2.9 percent in 2019, it is predicted that COVID-19 will cause GDP growth to decrease by three percent in 2020 [1]. World stock markets have experienced a large crash in the first quarter of 2020. Concerns about a further plunge of stock prices prevailed over global markets. However, due to the economic policies of each country, stock prices of world markets have turned from falling to rising in Mar. 2020.

It can be easily inferred that there is a difference in the degree of collapse and recovery reflecting the situation in each country. What is missing is a comparison of the stock price fluctuations of world markets from a statistical point of view. In addition, because it is rare for the world stock price indexes to fall all at once and then recover, we come up with the idea of analyzing the history of the world stock price plunge and surge to deepen our understanding of stock price movements. This study discusses a comparison of representative stock indexes of the U.S., European, and Asian markets [2]. Specifically, we focus on Dow Jones Industrial Average (DJIA), Nasdaq Composite Index (NASDAQ), France Stock Index (CAC), German Stock Index (DAX), Shanghai Composite Index (SSEC), and Nikkei Stock Average (Nikkei). Daily historical data are used for the research.

Dimson et al. [3] recommend investing in the U.S. markets rather than emerging ones because of the growth rate of stock prices and the stability of the investment environment. Reference [4] compares profitability of the U.S. and Asian markets by simulations that find buy-timing using a candlestick pattern model consisting of six parameters. The results of the simulation shows that the profitability of the U.S. markets outperforms other markets. However, these studies were carried out before the spread of the COVID-19 coronavirus. There is no guarantee that the situation is the same after the pandemic.

Ngwakwe [5] estimates how COVID-19 infections affected world stock indexes, i.e., Euronext 100, SSEC, DJIA and S&P 500. The results of analyses show that SSEC has resilience to COVID-19 pandemic with profit in stock values during the first fifty days into the pandemic, while the other indexes experience adverse impact from the COVID-19 pandemic with a significant loss at that time period. All stock indexes experience a higher variability or fluctuation of stock market prices.

Verma, et al. [6] statistically analyze the impact of the COVID-19 outbreak on global economic development. The indicators used in the analyses include S&P500 stock index, crude oil, gold, and 20-year treasury bond. They find that S&P500 stock index experiences high uncertainty from Feb. 2019 to Apr. 2020, i.e., the latest month of their research.

This paper aims to analyze stock price fluctuations of approximately 245 trading days before and after the COVID-19 pandemic, and statistically compare degrees of impact on the world markets.

The findings of this research are as follows:

I. The six stock market indexes used for comparison experience bottom prices within a week, specifically four business days from Mar. 18 to 23. After that, they never fall below the bottom prices.
II. The stock price best recovered in NASDAC, followed by Nikkei and DJIA, which is considered to reflect the degree of impact of the COVID-19 spread on each market.
III. It is observed that the trajectory of 25-day average of difference between stock price and 5-day average reverses on the lowest price day. We propose an indicator to predict trend reversal based on the observation.

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Experimental results show that the proposed indicator correctly predicts at least a reversal of a stock price decline due to the COVID-19 outbreak.

The remainder of the paper is organized as follows. Section II gives the background of the candlestick chart. Section III shows the result of comparisons of the stock market indexes by the ratio of stock prices to the lowest price caused by the COVID-19 pandemic. Section IV presents the results of comparisons of stock price movements in terms of the average and standard deviation in statistics. Section V describes statistics of candlestick parameters around the lowest price. Section VI proposes and discusses an indicator that can properly predict stock price trend reversals. Section VII concludes the paper with our plans for future work.

II. CANDLESTICK CHART AND PRAMETERS

This section introduces formations of a candlestick chart. The candlestick attributes to be analyzed are identified.

A. Formation of Candlestick

As depicted in Figure 1, a daily candlestick is formed with the market's opening, high, low, and closing prices of a specific trading day [7]. The candlestick has a wide part, which is called *real body* representing the range between the opening and closing prices of that day's trading, as shown in Figure 1. The color of the *real body* represents whether the opening price or the closing price is higher. If the price rises, a hollow body is drawn suggesting *bullish* or buying pressure. Otherwise, a filled body is drawn suggesting *bearish* or selling pressure.

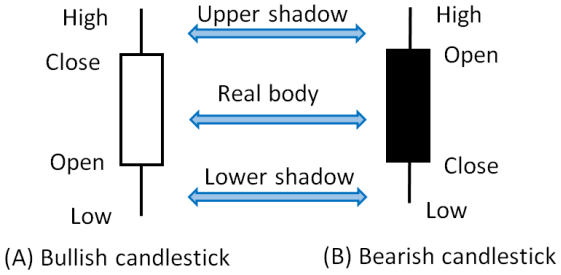

Figure 1. Candlestick formation

The thin lines above and below the body, which are named *shadows*, represent the range of prices traded in a day. The high is marked by the top of the upper shadow and the low by the bottom of the lower shadow.

B. Candlestick Chart and Parameters

A candlestick chart is a graph in which candlesticks are arranged in order of market days. It is used as a tool to get information on whether the current price is higher or lower than the historical stock price movements, and what kind of price movements have been made in a certain period of time. Moving averages form a line graph by connecting the average of closing prices over a certain period of time. The line graph is useful to decide whether stock prices are in a rising or falling trend by considering the relative position between the moving average and the current stock price. As for periods of time to compute averages, each country uses its own periods. For example, the short-term average is often calculated for 5 days, the medium-term average is for 25 days, and the long-term average is for 75 days in Japan.

Figure 2 illustrates indicators including averages that formalize a candlestick chart. In accordance with the candlestick chart notation, the following six attributes are used for analysis.

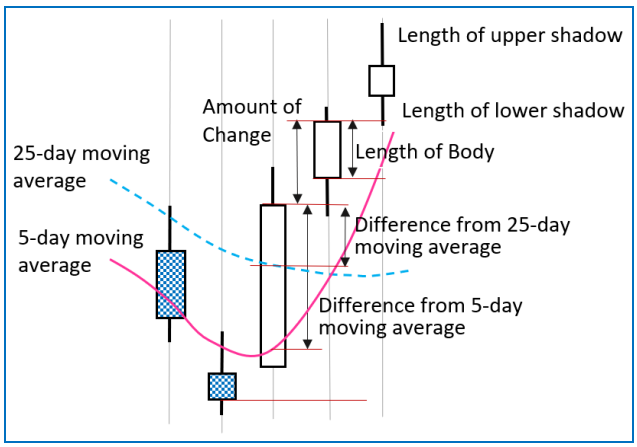

Figure 2. Candlestick chart and its parameters

(1) Amount of stock price change (the difference between a stock's closing price on a trading day and its closing price on the previous trading day)
(2) Length of candlestick body
(3) Length of upper shadow
(4) Length of lower shadow
(5) Difference between the stock price of a trading day and the 5-day moving average
(6) Difference between the stock price of a trading day and the 25-day moving average

III. COMPARISON OF STOCK INDEXES BY RATIO

This section describes the process of data analysis to follow how this research is performed. Stock price fluctuations of the six markets are compared concerning the lowest price during COVID-19 pandemic to understand impacts of COVID-19 on each market.

A. Data Analysis Process

Figure 3 overviews the data analysis process in this research that consists of the following operations.

(1) Downloading daily historical data from Web site
(2) Calculating the six attributes mentioned in Section II
(3) Extracting price data around the lowest price during COVID-19 pandemic
(4) Calculating 25-day average and standard deviation of the six attributes

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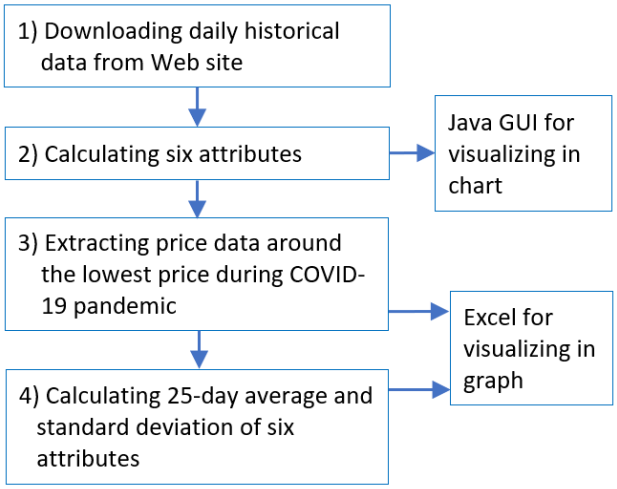

Figure 3. Overviews of data analysis process

Among the sites that provide global stock data, Web site [2] has provided useful daily stock data for more than 10 years in more than 40 markets. All data used in the research are downloaded manually.

Because the daily stock data only consist of close, open, high, low prices, and volume of stock trading, Java programs are developed for performing operations 2) to 4), and visualizing the candlestick chart. Excel is used for visualizing data of 3) and 4) in graphs.

B. Comparison of Stock Price Fluctuations

In order to understand overall structures of stock price fluctuations, we compare the stock price ratios to the lowest price that was recorded in Mar. 2020. Let CPr(n) be the closing price of a trading day n, and CPrMin be the lowest closing price recorded in Mar. 2020. The price ratio PrRatio(n) is calculated by the following formula, where CPr(1) represents the closing price of the latest trading day.

$$PrRatio(n) = (CPr(n) - CPrMin) * 100 / CPrMin \quad (1)$$

Figure 4 is a graph of the price ratio of the six markets' stock indexes for approximately 490 days from 245 days before the lowest price to the latest market day, i.e., Mar. 12, 2021. It shows that all stock indexes keep rising after the lowest price recorded in Mar. 2020.

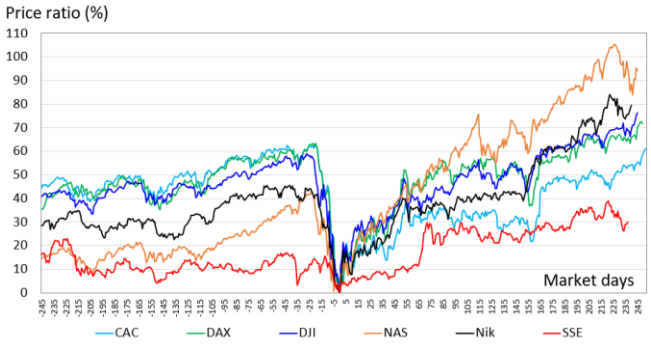

Figure 4. Ratio of stock index compared to the lowest price

Table 1 summarizes the stock price profiles compared to the lowest price. The lowest prices have been recorded from Mar. 18 to Mar. 23 in the six markets under comparison. Since Mar. 22, 2020 is Sunday, they show that the stock trends reversed from downtrend to uptrend in just 4 trading days in the six markets. The degree of plunge is 63.34% in DAX (Germany), followed by 62.76% in CAC (France), and 58.95% in DJIA (US), as shown in the column "highest price of pre-corona." The lowest decline was of 22.95% in SSEC (China).

TABLE I. SUMMARY OF STOCK PRICE INDICATORS COMPARED TO THE LOWEST PRICE

	Day of lowest price	Highest price of pre-corona (%)	Highest price of post-corona (%)	Recovery (%)
CAC40(France)	Mar. 18	62.76	61.03	-1.73
DAX(Germany)	Mar. 18	63.34	72.59	9.25
DowJones(U.S.)	Mar. 23	58.95	76.3	17.35
NASDAQ(U.S.)	Mar. 23	43.09	105.45	62.36
Nikkei(Japan)	Mar. 19	45.49	84.06	38.57
SSEC(China)	Mar. 23	22.95	38.94	15.99

A matter worthy of note is the degree of recovery from the lowest price. NASDAQ achieves the finest recovery of 62.36% rise as the highest price ratio after the corona is 105.45%, and the highest price ratio before the corona is 43.09%. Following NASDAQ, Nikkei (Japan) comes back by 38.57% rise. The slowest recovery is recorded –1.73% in CAC, followed by 9.25% in DAX. From the stock price movements of the two markets, it can be inferred that the impact of COVID-19 pandemic in Europe is larger than the other regions.

IV. COMPARISON BY AVERAGE AND STANDARD DEVIATION

This section presents the results of comparisons of the six market indexes adopted in this research with respect to the average and standard deviation in statistics. In order to compute the meaningful standard deviation, we calculate the average and standard deviation of the past 25 days [8] including the reference trading day. This period is commonly used for the calculation of the six attributes of a candlestick.

A. Amount of Stock Price Change

Figure 5 shows a graph of the 25-day moving averages and standard deviations of price changes of each stock market. As seen at the center part of Figure 5, the averages (in solid lines) of stock price changes plummet during approximately 20 days before the lowest trading day, i.e., around Feb. 20 in the five markets excluding SSEC. Stock price averages rally for approximately 25 days after the bottom, i.e., around April 24.

The standard deviations (in dashed lines) over this period, also increase in the range of 3.5 to 6 times of those of the other period reflecting the high volatility of price movements.

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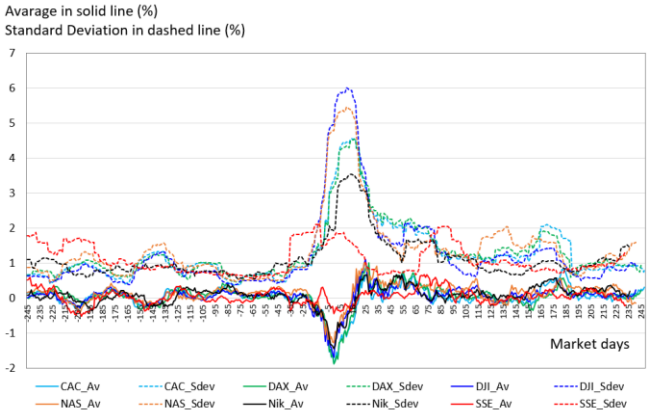

Figure 5. Average and standard deviation of price change

Taking a closer look at the standard deviations, DJIA reaches the maximum of 6.00%, followed by NASDAC of 5.47%, CAC of 4.56%, DAX of 4.54%, Nikkei of 3.53%, and SSEC of 2.14%, which is considered to reflect the strength of the impact on each market. The standard deviations of each market have roughly doubled after the lowest price, i.e., the right part, compared to those before the lowest price, i.e., the left part, which suggests that unstable trading has continued for roughly 180 days after the lowest price day.

B. Length of Candlestick Body

Figure 6 shows the 25-day averages and standard deviations of the candlestick lengths of the six stock markets. Figure 6 shows that the averages of SSEC are positive (plus) during the plunge period (–20 to 0), which means stock prices increase on average within a market day. The 25-day average of candlestick body lengths in NASDAQ is almost zero level during the plunge period. NASDAQ has consistently positive average during the period of stock price recovery (0 to 25), which means that the stock price continued to rise during trading hours. The four other markets experience remarkable negative averages, e.g., –1.39% in CAC, –1.15% in DAX, –0.967% in Nikkei, and –0.83% in DJIA at the lowest, suggesting that colored candlesticks are noticeable.

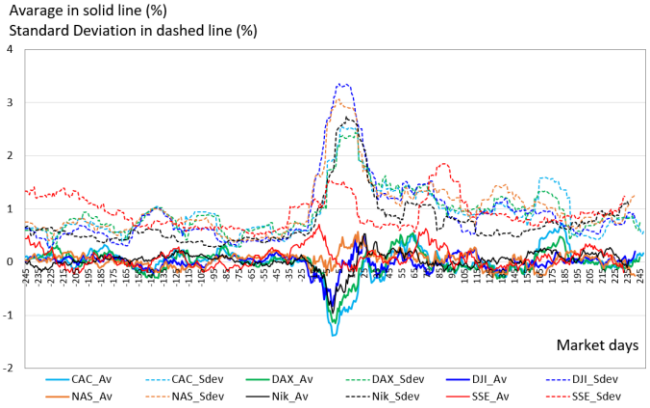

Figure 6. Average and standard deviation of candlestick body length

The largest standard deviation of 3.36% is marked in DJIA, followed by 3.07% in NASDAQ, 2.73% in Nikkei, 2.54% in CAC, 2.44% in DAX, and 1.85% in SSEC. Trends of the average and standard deviation of SSEC are notably different from the other markets.

C. Length of Upper and Lower Shadows

Figures 7 and 8 illustrate the 25-day averages and standard deviations of the lengths of the upper and lower shadows. The two figures look similar, revealing that the lengths of upper shadows are apparently correlated with those of the lower shadows.

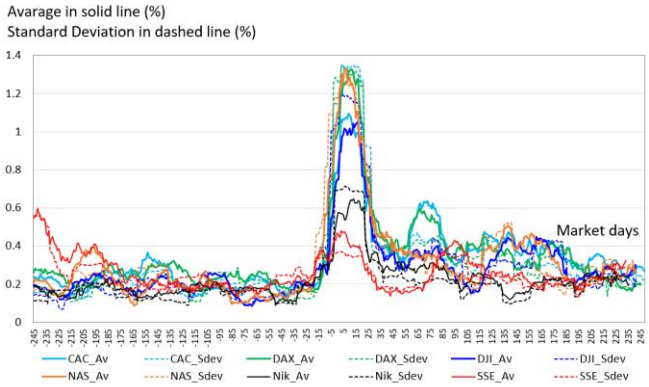

Figure 7. Average and standard deviation of upper shadow length

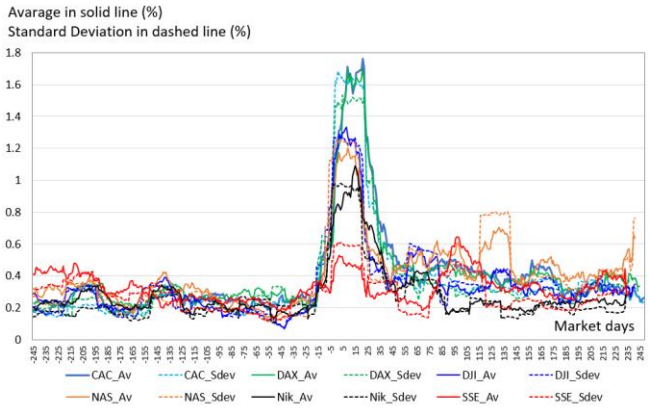

Figure 8. Average and standard deviation of lower shadow length

In the five markets excluding SSEC, the averages and standard deviations of the upper and lower shadows increase sharply during the period from approximately 10 days before the lowest price to approximately next 25 days.

Notably in the European markets of DAX and CAC, both the averages and standard deviations have surged about six times after the lowest price compared to these before the lowest price for the upper shadows, and about eight times for the lower ones. Those surges mean that rough price movements occur during the period.

On the other hand, the Asian market is relatively stable. In SSEC, the averages and standard deviations of shadows are doubled after the lowest price than before for the upper

shadows, and are tripled for the lower ones. Nikkei marks about three times higher for the upper shadows, and about five times higher for the lower ones.

Figure 9 is a scatter plot of the lengths of upper and lower shadows in the Nikkei market. It illustrates that there is a strong correlation between the lengths of the upper and lower shadows.

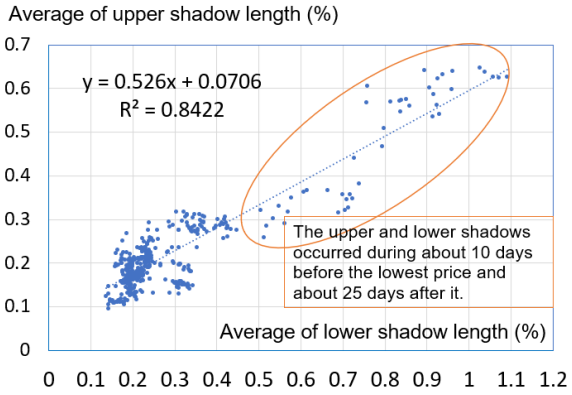

Figure 9. Scatter plot of upper and lower shadow length of Nikkei

The points surrounded by an ellipse correspond to the shadows that occur in the period between approximately 10 days before and approximately 25 days after the lowest price. These points occupy a different portion of Figure 9 from the rest of the points. *R Square* in statistics is 0.8422, which indicates that 84.22% of the upper shadow length can be explained by the lower shadow length, and vice versa.

D. Difference Between Stock Price and 5-day Average

Figure 10 shows the 25-day averages and standard deviations of the "difference between a stock price and 5-day moving average" for the six markets. The 25-day averages of the differences sharply decreased during approximately 20 days before the day that record the lowest, and increases approximately 25 days after the bottom.

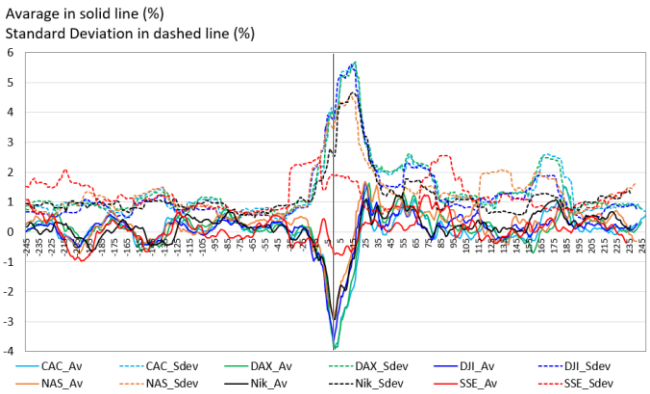

Figure 10. 25-day average and standard deviation of "difference between stock price and 5-day average"

In the five markets excluding SSEC, the day when the 25-day average of the "difference between a stock price and 5-day moving average" reverses the trend from downward to upward roughly coincides with a day when the stock price bottoms out. This is an important finding and detailed analyses are discussed in Section VI. The standard deviations almost reach their maximums during the period.

E. Difference Between Stock Price and 25-day Average

Figure 11 shows the 25-day averages and standard deviations of the "difference between a stock price and 25-day moving average" for the six markets. The graphs have a smooth shape as a whole reflecting the fact that the difference is computed between a stock price and 25-day moving average.

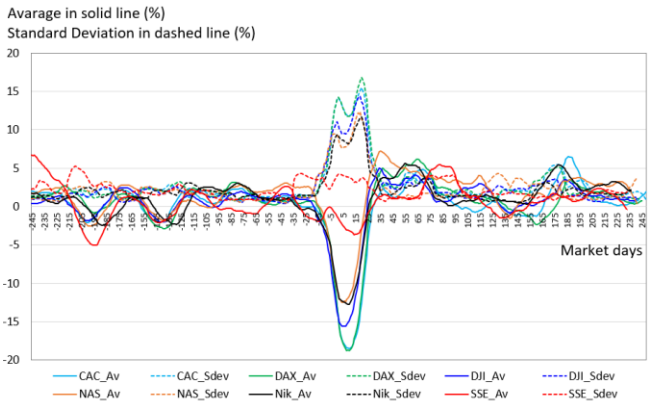

Figure 11. 25-day average and standard deviation of "difference between stock price and 25-day average"

Again, in the five markets excluding SSEC, the averages and standard deviations fluctuate largely during a period between approximately 20 days before the day that recorded the lowest price and the next 25 days.

V. STATISTICS OF PARAMETERS AROUND LOWEST PRICE

The averages and standard deviations of each attribute are examined to find out how the COVID-19 affects each market in 25 days before and after the lowest price day.

A. Amount of Stock Price Change

Figure 12 shows the average and standard deviation of the stock price change. All averages are negative 25 days before the lowest price day and positive after the day.

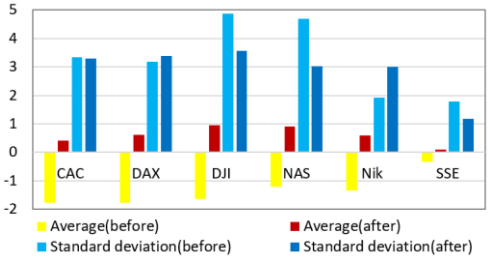

Figure 12. Average and standard deviation of stock price change

The largest average price change is 2.58% in DJIA as the result of the change from –1.63% to 0.95%, followed by 2.39% in DAX, 2.19% in CAC, 2.13% in NASDAQ, 1.94%

in Nikkei, and 0.434% in SSEC. The standard deviations notably decreased in Dow and NASDAQ with suggestion of stabilization of trading.

B. Length of Candlestick Body

Figure 13 shows that the averages of candlestick body lengths reverse the trend from negative to positive before and after the lowest price day in the four markets except for CAC and SSEC. The statistics of trend reversal indicate that there are many opportunities when stock prices rise during trading days after the lowest price day. The average after the day of the lowest price in CAC is –0.1388% for reference purposes. The averages in SSEC keep positive, i.e., 0.112% before the day of the lowest price, and 0.0489% after it.

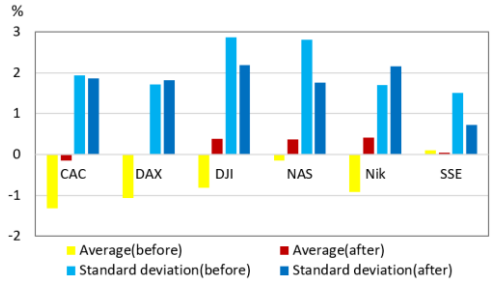

Figure 13. Average and standard deviation of candlestick body lengths

The standard deviations conspicuously decreased in DJI and NASDAQ, which are the same tendency as in the stock price changes.

C. Length of Upper and Lower Shadows

Figures 14 and 15 show the averages and standard deviations of the upper and lower shadows in the six markets. In all markets, the upper shadows have larger averages and standard deviations before the lowest price day than those of after the day.

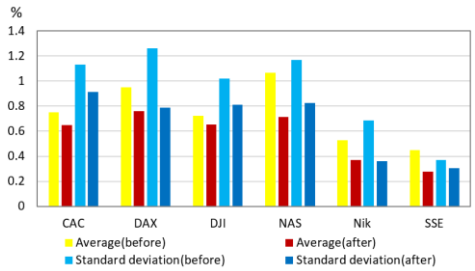

Figure 14. Average and standard deviation of length of upper shadows

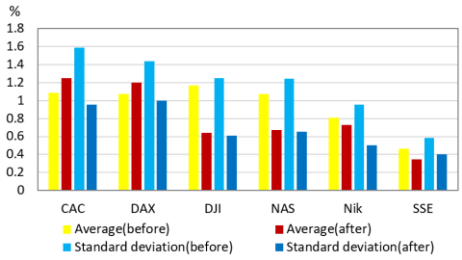

Figure 15. Average and standard deviation of length of lower shadows

The same tendency as the statistics of the upper shadows is observed in those of the lower shadows. However, the averages of the lower shadows increase by approximately 0.3% after the lowest price in CAC and DAX, while they decreased in the other markets.

D. Difference Between Stock Price and 5-day Average

Figure 16 shows the averages and standard deviations of "difference between a stock price and 5-day average." In the five markets excluding SSEC, the averages turn over from –3% or less to approximately 1%. SSEC have far less average change of 0.835% than the other markets, e.g., 3.70% of Nikkei.

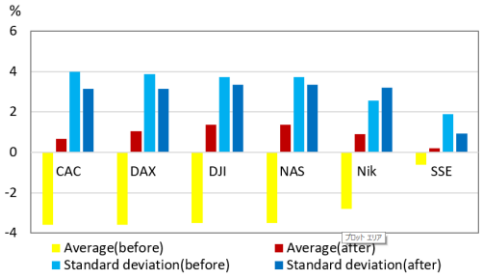

Figure 16. Average and standard deviation of "difference between stock price and 5-day average"

The five markets excluding Nikkei have slight reduction in the standard deviations roughly from 0.4% to 0.9%.

E. Difference Between Stock Price and 25-day Average

Figure 17 shows the averages and standard deviations of "difference between a stock price and 25-day average." The averages in CAC and DAX noticeably remain negative, i.e., –6.05% in CAC and –4.47% in DAX, after the lowest price day, which is deemed to reflect the delay in the recovery of markets.

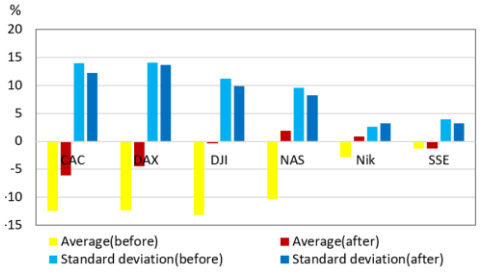

Figure 17. Average and standard deviation of "difference between stock price and 25-day average"

Meanwhile, NASDAQ achieves a positive average of 1.89%, indicating that the stock price steadily recovered compared to the other five markets.

VI. Examining Signals of Trend Reversal

As mentioned in Section IV-D, the 25-day average of "difference between a stock price and 5-day moving average" starts to rise just after the day when the lowest price is recorded. This section discusses that this indicator can properly predict stock price trend reversals. Java

programs using Swing packages are developed in order to perform the analysis efficiently.

Let CPr(n) be the closing price of a trading day n, and CPr(1) be the closing price of the latest trading day. CPr(1) represents the current stock price in the case of trading hours.

25-day average of "difference between a stock price and 5-day moving average" is defined by the following formula:

$$\text{CPAvg (n, 25, 5)} = \frac{1}{25}\sum_{j=n}^{j=n+24} \{ CPr(j) - \frac{1}{5}\sum_{k=j}^{k=j+4} CPr(k) \} \quad (2)$$

Analogously, 5-day average of the difference is defined by the following one:

$$\text{CPAvg (n, 5, 5)} = \frac{1}{5}\sum_{j=n}^{j=n+4} \{ CPr(j) - \frac{1}{5}\sum_{k=j}^{k=j+4} CPr(k) \} \quad (3)$$

Figure 18 illustrates the candlestick chart for 30 days before and after Mar. 18, 2020 in the DAX market. The magenta line at the bottom of Figure 18 shows CPAvg (n, 5, 5), and the blue line shows CPAvg (n, 25, 5).

Figure 18. Candlestick chart for 30 days before and after Mar. 18, 2020 in DAX market

The proposed two average lines go across up on Mar. 19, i.e., the next day when the lowest price is recorded. The two lines do not crossover on Mar. 5, which predicts that stock prices will continue to fall. In other words, a short-term recovery from Feb. 28 to Mar. 5 is a "dead cat bounce," i.e., a temporary recovery of stock prices during a prolonged decline period.

The two lines also do not crossover during the decline from Mar. 27 to April 3, which suggests that Apr. 3 is a "buying on the dips" type of opportunity since the difference of the two lines increase on Apr. 3. The magenta line crosses down through the blue line on Apr. 17. However, given that the stock remains above the 25-day average with a margin, the two average lines suggests that we should not take any action for a down trend.

Similar results have been obtained in the other markets. Regarding recovery from the plunge caused by COVID-19, it is confirmed that the proposed two average lines forecast short-term trends properly.

VII. Conclusion and Future Work

This paper describes the results of analyses of stock price fluctuations in European, the U.S. and Asian markets with special focus on the effects of COVID-19 pandemic. In general, thanks to the timely implementation of monetary measures of each country, all stock indexes under study keep rising after the lowest price recorded in Mar. 2020.

As of Mar. 12, 2021, the NASDAQ Composite Index (U.S.) of post-corona recovered 62.36% higher price compared to the highest price of pre-corona, while CAC (France) decreased by –1.73%. Analyses of the average and standard deviation of the six attributes that characterize the candlestick chart reveal that CAC and DAX (Germany) are deemed to experience a larger impact on stock prices than the other markets.

We propose an indicator consisting of a pair of moving averages. The indicator is devised in the process of investigating how the difference between the stock price and 5-day average is related to the reversal of stock trends. The results of experiments using daily stock indexes under study show that the proposed indicator forecasts short-term trends properly with a short time lag, at least as far as the stock price plunge caused by COVID-19 is concerned.

We are planning comparative studies with well-known indicators including MACD (Moving Average Convergence Divergence) and ADX (Average Directional Index) [7] to inspect the effectiveness of the proposed indicator. The study may use daily historical stock data of various global stock markets and individual companies over different periods of time.

References

[1] A. Chudik, K. Mohaddes, M. H. Pesaran, M. Raissi, and A. Rebucci, "Economic consequences of Covid-19: a counterfactual multi-country analysis," Available from: https://voxeu.org/article/economic-consequences-covid-19-multi-country-analysis/ Oct. 2020.

[2] "Major World Market Indices," Available from: https://www.investing.com/indices/major-indices/ Mar. 2021.

[3] E. Dimson, P. Marsh, and M. Staunton, "Should you invest in emerging markets?" London Business School, Available from: https://www.london.edu/ think/emerging-markets/ Apr. 2019.

[4] Y. Udagawa, "Statistical Analysis of Stock Profits to Evaluate Performance of Markets," The Sixth International Conference on Big Data, Small Data, Linked Data and Open Data (ALLDATA 2020) IARIA, pp. 14–21, Feb. 2020.

[5] C. C. Ngwakwe, "Effect of COVID-19 Pandemic on Global Stock Market Values: A Differential Analysis," Acta Universitatis Danubius. Œconomica, No 2, Vol 16, pp. 255-269, 2020.

[6] P. Verma, A. Dumka, A. Bhardwaj, A. Ashok, M. C. Kestwal, and P. Kumar, "A Statistical Analysis of Impact of COVID19 on the Global Economy and Stock Index Returns," Springer Nature journal Computer Science,2:27, pp. 13, Jan. 2021.

[7] "Technical Analysis," Cambridge Univ., Available from: http://www.mrao.cam.ac.uk/~mph/Technical_Analysis.pdf, pp. 1-179, Feb. 2011.

[8] S. Glen, "Statistics How To, T-Distribution/Student's T: Definition, Step by Step Articles," https://www. statisticshowto.com/probability-and-statistics/t-distribution/ 2020.

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