Forecast and Analysis for Stock Market of the U.S, Canada, and Mexico Based on Time Series Forecasting Models

Lin Tian[1,a,*]

[1]*University of California, San Diego, La Jolla CA 92092, USA*
a. l4tian@ucsd.edu
*corresponding author

Abstract: Forecasting the stock market index has been an essential part of the investing process for the world's investors, so predication for the composite stock market index of three different countries in North America were made for the investors to get references. The weekly data of three representative composite stock market index for each country from the past three months were chosen to generate the prediction for the next week's performance of the stock market in each country through different time-series forecasting methods. The correlation between each index are calculated, indicating the short-term relationship between each country's stock market. Three time-series predicting method is produced: SMA, WMA, and SES, one of the three methods with the least error by comparing the MSE and MAD would be selected for each stock index. Analyze the forecast results from the selected method for each country's composite stock market index and compare them. The forecast results show that the composite stock market index for all three countries is going to decline in the following week. Several short-term relationships between different countries' stock markets are revealed. The results and the discussion of this research tend to serve as a reference or an indicator for investors who have interests in multiple countries' stock markets in the world.

Keywords: time-series forecasting, composite stock market index, correlation, North American stock markets

1. Introduction

Forecasting the stock market index has brought attention to the world's investors in recent decades. The forecasting results for the stock chosen serve as important parameters to the investors. In nowadays increasing financial market volatility, better forecasting leads to better financial decision making [1]. Furthermore, more and more investors have put their eyes on foreign stock markets, searching for more opportunities [2]. Some of the investors don't limit their insight within their own country's stock market, but they also show interest in the stock market of other countries. One of the reasons behind this is to reduce the risk of the investment, which is also a critical part of the investing process. If the investors have the knowledge of the stock markets in other countries, they may choose to invest in foreign stock markets in case of their own country's stock is going through a recession, lowering the risk. In other words, an international portfolio could reduce risk to some degree [3]. In order to help the investors acquire more information about the stock markets in the world, more

research and analysis on international stock markets should be performed. For example, from Clark and Berko [4], Mexico stock market has been an emerging market with returns associated with foreign market fluctuations. Mexico stock market is one of the major North American stock markets. For more information on the world's stock markets, more studies within the North America stock market should be contributed.

In this research, the representative composite stock market indexes are forecast for the major countries in North America: the U.S, Canada, and Mexico. Along with the forecast results, an analysis of the relationship between each stock market is also performed for more insights. With all the information above, investors could make better financial decisions on when and whether they should invest in foreign stock markets. There are many types of forecasting methods. As for quantitative analysis with little knowledge of the volatility of the stock markets, time series forecasting would be useful to forecast the stock market index. The Time series forecast method uses past data or observations to find the underlying relationship and generate predictions for the future [5]. Investors take the forecasting results for reference to make critical financial decisions. Thus, for this research, time series forecasting would also be applied to predict the future performance of the foreign stock market selected.

The main focus of this research is to predict a stock index representing the whole country's stock market performance for each selected country: the U.S, Canada, and Mexico. Three types of time series forecasting models would be utilized for the prediction of each country's stock market: Simple Moving Average (SMA), Weighted Moving Average (WMA), and Single Exponential Smoothing (SES). The model that produces the least error of estimation among the three models would be selected as the forecast result for the given country's stock market. Mean Absolute Deviation (MAD) and Root Mean Squared Error (RMSE) would be used as the parameters of error performed in the estimation. In addition to forecasting, the short-term relationships between each country's stock market would be analyzed using correlation coefficients as an indicator.

The main takeaway of this research is that all stock markets researched have a declining inclination in the following week, meaning all three markets: the U.S, Canada, and Mexico, would have a negative stock return in the short term. The short-term correlation between the Mexican and American stock markets and the Canadian stock market is positive. but Mexico stock market doesn't show a strong correlation with the American stock market in the short run. For further demonstration below, data and methodology would be explained in detail first. Then the result of each model would be presented after the methodology. After that, a conclusion would be drawn from the results with further discussions and suggestions.

2.   Data

First of all, one composite stock market index is selected for each country. The selected composite stock market index should be the representative index for the country's overall stock market. For the United States, S&P 500(^GSPC) is a good indicator for the U.S stocks market as it is frequently cited as the top single indicator of large-cap U.S. stocks [6]. As the headline index for the Canadian equity market [7], the S&P/TSX Composite index (^GSPTSE) is chosen to represent the Canada stock market. For the Mexican stock market, IPC MEXICO (^MXX) is used as it is a major stock index in Mexico that monitors the performance of top corporations listed on the Mexican Stock Exchange [8]. After selecting the stock index needed, the adjusted closing price each week for each stock index from the past three months (05/02/2022-08/23/2022) are collected from Yahoo Finance that give enough information to forecast for the prices of the following week [9]. The forecast results are only for the following week due to the volatility of the stocks. The stock markets are too unstable to be predicted to a more extended period. Such forecast for a longer term in stock markets could be much

guaranteed to be similar to the actual performance. All the stock prices are converted into US Dollars for convenience, as shown below in Table 1.

Table 1: The adjusted closing price (in US dollar) each week for S&P 500, S&P/TSX, and IPC MEXICO.

Date	S&P 500(U.S)	S&P/TSX(Canada)	IPC MEXICO(Mexico)
2022/5/2	4123.34	16093.97	2477.0904
2022/5/9	4023.89	15677.8446	2478.9949
2022/5/16	3901.36	15754.1277	2575.915
2022/5/23	4158.24	16183.9077	2623.1775
2022/5/30	4108.54	16216.7454	2534.4525
2022/6/6	3900.86	15814.3446	2423.576
2022/6/13	3674.84	14765.79	2400.8115
2022/6/20	3911.74	14869.0623	2387.075
2022/6/27	3825.33	14711.8923	2387.1574
2022/7/4	3899.38	14837.8623	2379.1055
2022/7/11	3863.16	14347.71	2353.7936
2022/7/18	3961.63	14806.6623	2363.243
2022/7/25	4130.29	15360.4623	2407.2164
2022/8/1	4145.19	15303.6777	2336.1715
2022/8/8	4280.15	15740.2446	2442.6686
2022/8/15	4228.48	15686.8923	2423.1631
2022/8/22	4140.77	15616.6923	2372.4865

The data above would be the primary source for the research. The weekly price of the past three months is used to forecast the performance of each country's stock market for the following week (08/23/2022-08/29/2022). The correlation index analysis is all based on the data above.

3. Methodology

3.1. Stationary Test Methods

After all the data have been converted into the same currency and unit, a stationary test is performed. In the most intuitive sense, a stationary test helps tell whether a set of time series data is stable or not. Followed by Mader and Nason, a stationary process is one whose statistical properties do not change over time [10]. If the result is non-stationary, that means there may be an unexpected impact over time, leading to the non-stationarity of the prediction. For stock prediction, the non-stationarity of a stock index means a forecast made for a longer period would not be accurate due to the high volatility of the stock's future performance. In this research, the stationary test is performed for all three stock market indexes chosen. For the stationary test, two methods are used:

Panel Visualization. The first method is panel visualization which will be the line graph of the time series data. The data is non-stationary if the graph shows upward or downward trends like in Figure.1, but sometimes it may be hard to tell whether a set of time series data is stationary accurately just by looking at trends.

Figure 1: Example of a non-stationary time series data line graph.

Autocorrelation Function (ACF). Thus, the second part of the test: Autocorrelation Function (ACF) is introduced for further examination. Autocorrelation function calculates the correlation of a set of time series data with a delayed copy of itself. The correlation of each observation is shown by a graph called correlogram (see Figure 2). Each bar (or lag) on the graph represents the difference between each data and the delayed copy of itself. Denoted by Palachy, when looking at the correlogram, the values of the lags often degrade to zero quickly for stationary time series, but more slowly for non-stationary data [11]. For this research, a correlogram is generated for each of the country's stock market.
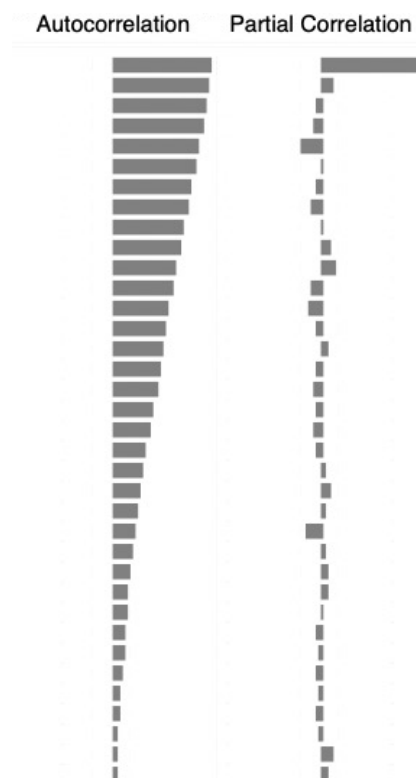

Figure 2: Example of an ACF correlogram.

3.2. Time-series Forecasting Models

After testing the stationarity for each stock index, three of the time series forecast models are applied to predict the performance of each country's stock market for the following week.

Simple Moving Average (SMA). Simple moving average (SMA) could be used as a forecast model for time series data. Sani and Kingsman (1997) conducted that SMA is widely preferred as a forecasting method due to its simplicity [12]. To calculate this moving average, add up all the figures from given periods and divide it by the total number of the periods. The Equation is displayed below:

$$SMA = \frac{a_1 + a_2 + a_3 + \cdots + a_n}{n} \tag{1}$$

where n is the total number of the periods and a_n is the price of the stock at period n.

For this research, the simple moving average is calculated by adding the prices from the previous 3 weeks and then dividing that figure by 3. In this way, the forecast price for the following week (08/29/2022) would be produced.

Weighted Moving Average (WMA). Weighted moving average (WMA) is also a reliable forecast model for time series data. According to Zhuang et al. in 2007, the WMA model selects more samples to generate a certain value that is crucial to the moving average. At the same time, WMA gives it a greater confidence weight so that the moving average can quickly reflect this crucial value. [13]. To calculate this moving average, within given periods, time the price at a period with a certain weight and add up the product. The sum of the weights should be equal to 1. The Equation is displayed below:

$$\begin{cases} WMA = W_1 a_1 + W_2 a_2 + W_3 a_3 + \cdots + W_n a_n \\ W_1 + W_2 + W_3 = 1 \end{cases} \tag{2}$$

where n is the total number of the periods, W_n is the weight for period n, and a_n is the price of the stock at period n.

For this research, WMA is calculated as the sum product of prices from the previous 3 weeks with three weights that add up to 1. The specific selection for the value of each weight would be explained later. In this way, the forecast price for the following week (08/29/2022) would be produced.

Single Exponential Smoothing (SES). Single Exponential Smoothing (SES) could be a trusted forecast model as it is also the most used forecasting skill [14]. Summarized by Rachmat and Suhartono in 2020, SES is a method that gives an exponential weighted moving average for previous observations and shows no impact by the trend and the season [15]. It is a weighted average method that weights recent results more heavily. To calculate the forecast price, use the equation below:

$$\begin{cases} F_n = F_{n-1} + \alpha(a_{n-1} - F_{n-1}) \\ a \leq 1 \end{cases} \tag{3}$$

where α is the Smoothing constant, F_{n-1} is the forecast price made for the prior period, a_{n-1} is the actual price of the prior period, and F_n is forecast price for period n.

For this research, the Single Exponential Smoothing forecast of the first week is the actual price of the first week as there is no prior week. α is a constant that is smaller or equal to one. The specific selection for the value of α would be explained later. In this way, the forecast price for the following week (08/29/2022) would be produced.

3.3. Forecasting Error

Mean Absolute Deviation (MAD). Mean Absolute Deviation (MAD) is a parameter that measures the error of the forecast model. It is the mean of the absolute difference between the actual prices and the forecast prices. The Equation is shown below:

$$MAD = \frac{\sum_{p=1}^{n}|a_p - F_p|}{n} \tag{4}$$

where a_p= is the actual price at period p, F_p is the forecast price made for period p, and the overall number of observations is n.

For this research, MAD is calculated by adding up the difference between the actual price and the forecast price of each week and then taking the average of the sum, which produces the same result as the equation does.

Root Mean Squared Error (RMSE). Root Mean Squared Error (RMSE) is a universal error parameter for forecasting models. RMSE could be used as a standard statistical metric to measure model performance for the stock index as it provides unbiased errors that followed a normal distribution, giving a complete picture of the error distribution [16]. In order to calculate it, one needs to first sum up the squared difference between the actual prices and the anticipated prices. Then divide the total by the number of data. The Equation is shown below:

$$RMSE = \frac{\sum_{p=1}^{n}(a_p - F_p)^2}{n} \tag{5}$$

where a_p is the actual price at period p, F_p is the forecast price made for period p, and the overall number of observations is n.

For this research, RMSE is calculated by adding up the squared difference between the actual price and the forecast price of each week and then taking the average of the sum or just simply squaring MAD, which produces the same result as the equation does.

Continuing from how to decide the weights for WMA and the value of α for SES. For both MAD and RMSE, it is the smaller the better and more accurate the forecast model performs. Thus, a solver method is applied to the data for both WMA and SES models. A tool called Solver Parameter within Excel is used to achieve the goal. The goal is to find the minimized MAD and RMSE by changing the weights for WMA and the value of α for SES, minimizing the error for each model. After the solver is applied, the MAD and RMSE of each model are compared, and the model with the least MAD and RMSE is selected for the forecast result as the chosen model produces the least error.

3.4. Correlation

Correlation could be described as the degree of association between two variables [17]. In stock markets, correlation can also be discovered between two stocks. Correlation coefficient is one of the indicator for correlation. By calculating the correlation coefficient between each stock index, the short-term relationship between each stock would be revealed. The absolute value of the coefficient is lower or equal to 1. A positive coefficient approaching to the value of 1 is an indication of strong short term relationship with positively proportionally impact, and vice versa. The equation is shown below:

$$r_{ab} = \frac{Cov(a,b)}{\sigma_a \sigma_b} \tag{6}$$

where the correlation coefficient between *a* and *b* is r_{ab}, covariance of *a* and *b* is *Cov(a,b)*, the standard deviations of *a* and *b are* respectively σ_a and σ_b.

For this research, the correlation coefficient is calculated for each stock between one another. The correlation coefficient serves as an indication for the short-term relationship between two countries stock markets.

4. Results

4.1. Stationary Test Results

Panel Visualization. The line graph below shows the visualization part of the stationary test (See Figure 3).
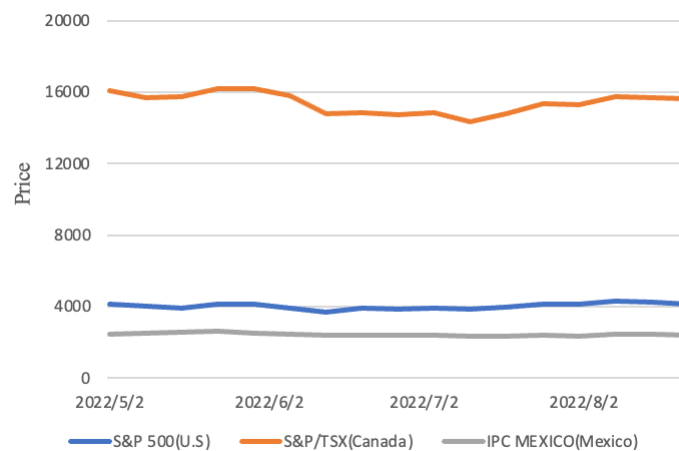

Figure 3: Line graph for the adjusted closing price each week for S&P 500, S&P/TSX, and IPC MEXICO.

According to the visualization stationary test, it seems all three stock indexes are relatively stable, showing the trend of stationary. However, for a more accurate result, the ACF test should be performed for assurance.

Autocorrelation Function (ACF). The ACF test result for each stock market index is shown below (See figure 4&5&6):
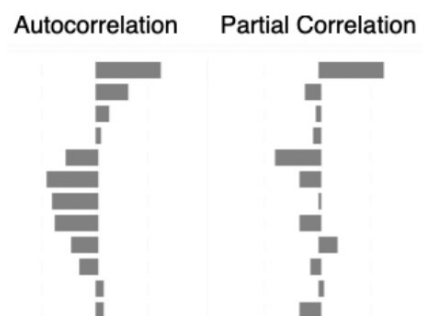

Figure 4: Correlogram for the adjusted closing price each week for S&P 500 (U.S).
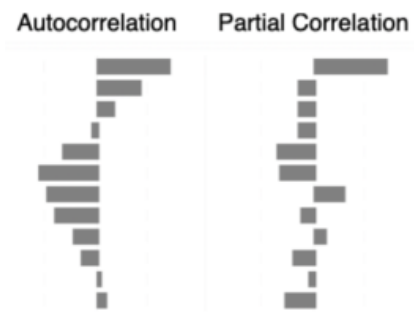
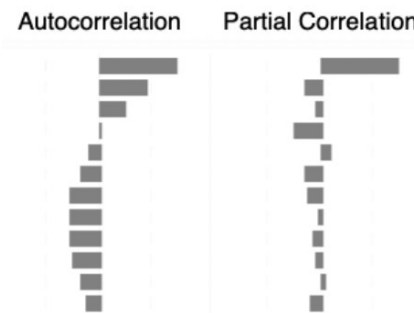Figure 5: Correlogram for the adjusted closing price each week for S&P/TSX (Canada).

Figure 6: Correlogram for the adjusted closing price each week for IPC MEXICO (Mexico).

Showed in the correlogram for the ACF test, the values tend to approach to zero slowly for all three stock markets. This result indicates that the data sets are non-stationary for all three stock markets. Otherwise, the value would degrade towards zero at the second lag if the data set is stationary. The results show the non-stationarity for tall three stock markets, and it is reasonable as each stock index selected represented for a whole country's stock market. The future performance of a nation's stock market could be impacted by a variety of underlying reasons or unanticipated effects. Additionally, the non-stationarity of all three stocks indicates that no longer-term forecast could be confidently referred. Forecasts should be applied for a shorter period like a week.

4.2. Forecasting Results (Three Models Comparison)

After the stationary test, the data sets are ready for the forecast models, see below for all three forecast model results for each country's stock market (See table 2&3&4)

The U.S Stock Market.

Table 2: Forecast results for S&P 500 with SMA, WMA, and SES.

Date	SMA	WMA	SES
2022/5/2			4123.34
2022/5/9			4123.34
2022/5/16			4055.9299
2022/5/23	4016.1967	3948.8143	3951.1579
2022/5/30	4027.83	4129.519	4091.5242
2022/6/6	4056.0467	4064.2495	4103.058
2022/6/13	4055.88	3955.8821	3966.0023
2022/6/20	3894.7467	3767.5554	3768.644
2022/6/27	3829.1467	3909.4141	3865.6386

Table 2: (continued).

2022/7/4	3803.97	3793.1586	3838.3163
2022/7/11	3878.8167	3902.0223	3879.7071
2022/7/18	3862.6233	3855.0728	3868.491
2022/7/25	3908.0567	3948.3223	3931.6233
2022/8/1	3985.0267	4073.1836	4066.2854
2022/8/8	4079.0367	4105.949	4119.7692
2022/8/15	4185.21	4248.1133	4228.48
2022/8/22	4217.94	4210.6744	4228.48
2022/8/29	4216.4667	4170.5663	4169.0276

Canada Stock Market.

Table 3: Forecast results for S&P/TSX with SMA, WMA, and SES.

Date	SMA	WMA	SES
2022/5/2			4123.34
2022/5/9			15677.8386
2022/5/16			15677.8444
2022/5/23	15841.9823	15754.1277	15751.4759
2022/5/30	15871.96	16183.9077	16168.875
2022/6/6	16051.5936	16216.7454	16215.0813
2022/6/13	16071.6659	15814.3446	15828.2754
2022/6/20	15598.96	14765.79	14802.7253
2022/6/27	15149.7323	14869.0623	14866.7562
2022/7/4	14782.2482	14711.8923	14717.2758
2022/7/11	14806.2723	14837.8623	14833.6703
2022/7/18	14632.4882	14347.71	14364.6035
2022/7/25	14664.0782	14806.6623	14791.295
2022/8/1	14838.2782	15360.4623	15340.6763
2022/8/8	15156.9341	15303.6777	15304.9639
2022/8/15	15468.1282	15740.2446	15725.1129
2022/8/22	15576.9382	15686.8923	15688.221
2022/8/29	15681.2764	15616.6923	15619.1789

Mexico Stock Market.

Table 4: Forecast results for IPC MEXICO with SMA, WMA, and SES.

Date	SMA	WMA	SES
2022/5/2			4123.34
2022/5/9			2477.9678
2022/5/16			2478.9944
2022/5/23	2510.6668	2570.2937	2575.8634
2022/5/30	2559.3625	2614.9761	2623.1523
2022/6/6	2577.8484	2536.811	2534.4998

Table 4: (continued).

2022/6/13	2527.0687	2434.9298	2423.6351
2022/6/20	2452.9467	2408.4133	2400.8237
2022/6/27	2403.8208	2389.1512	2387.0823
2022/7/4	2391.6813	2387.9341	2387.1574
2022/7/11	2384.446	2379.5588	2379.1098
2022/7/18	2373.3522	2355.6914	2353.807
2022/7/25	2365.3807	2364.1453	2363.2379
2022/8/1	2374.751	2404.1776	2407.193
2022/8/8	2368.877	2337.7114	2336.2093
2022/8/15	2395.3522	2440.652	2442.6118
2022/8/22	2400.6677	2418.2148	2423.1735
2022/8/29	2412.7727	2376.4786	2372.5135

4.3. Forecasting Error Results (Three Models Comparison)

Of the following are the MAD and RMSE produced from each model for each country (See Table 5&6&7):

The U.S Stock Market.

Table 5: Forecast error results of SMA, WMA, and SES for S&P 500.

S&P 500	MAD	RMSE
SMA	120.99	24195.19
WMA	119.46	19707.31
SES	108.9	18617.78

Canada Stock Market.

Table 6: Forecast error results of SMA, WMA, and SES for S&P/TSX.

S&P/TSX	MAD	RMSE
SMA	434.97	289770.65
WMA	315.7	175542.07
SES	965.38	8575090.04

Mexico Stock Market.

Table 7: Forecast error results of SMA, WMA, and SES for IPC MEXICO.

IPC MEXICO	MAD	RMSE
SMA	54.57	4934.87
WMA	44.68	3172.71
SES	138.95	162619.8

Comparing the error of each forecasting model for each country, the WMA forecast model produces the least error for Mexico and Canada stock market, while for the U.S stock market, SES forecast model generates the least error.

4.4. Correlation Results

The correlation coefficient table showing the short-term relationship between each stock market (see table 8):

Table 8: Correlation coefficient between S&P 500, S&P/TSX, and IPC Mexico.

	S&P 500	S&P/TSX	IPC MEXICO
S&P 500	1		
S&P/TSX	0.659	1	
IPC MEXICO	0.2379	0.7397	1

In the short run, the result shows a positive relationship between the U.S. stock market and the Canadian stock market with a relatively strong strength, and a positive correlation between the Canadian stock market and the Mexican stock market with a strong connection. However, the U.S stock market appears to have a weak correlation with Mexico market.

4.5. Finalized Results

Thus, the overall forecast result for the following week (08/29/2022) is presented below (see table 9):

Table 9: Forecast price for S&P 500, S&P/TSX, and IPC MEXICO.

Forecast Price	S&P 500	S&P/TSX	IPC MEXICO
2022/8/29	4169.03	15616.69	2376.48

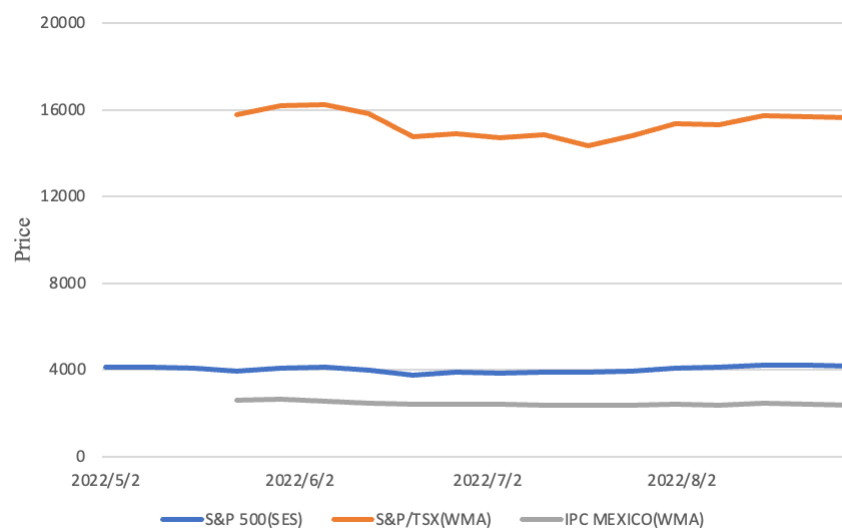The overall trend is shown in the graph below (see figure 7):

Figure 7: Line graph for the forecast price of S&P 500, S&P/TSX, and IPC MEXICO.

A slightly declining trend is shown in the graph for all three stock indexes, indicating the decreasing prices for all three countries stock markets.

5.   Conclusion

In recent decades, investors in the world have been developing interests in foreign stock markets other than their own country's market. Having an international portfolio leads to better risk management and more diversified assets. North America is one of the major continents in the world and takes a huge part in the world's stock markets. More research into the North American stock markets should be contributed to help people in the world learn more about the world's major stock markets. Such studies are also recommended for investors interested in foreign stock markets and who want to have suggestions for their financial decisions.

To analyze and forecast the North American stock markets, the most representative composite stocks of three major North American countries are selected for each country. The prices of each stock chosen from the past three months are used as primary sources for the forecast and analysis. Stationary tests are performed in the first place. Due to the non-stationarity of all three stocks, only a short-term forecast could be referred to confidently. Thus, forecasts are made for the following-week-performance of the selected stocks using three different time series forecasting models: SMA, WMA, and SES. MAD and RMSE are also generated as error indicators for the forecast models. Eventually, the model with the least MAD and RMSE for each stock is selected to be the forecasting model for that stock with relatively reliable results. In addition, the correlation between each stock is revealed in the correlation coefficient, indicating the short-term relationship between stocks.

As a result, the stock markets of the major countries in North America: The United States, Canada, and Mexico, have shown a declining tendency in the price for the following week based on the past three months' data. Investors may expect negative returns after investing in the stock within the stock markets of the three countries mentioned above. The finalized forecast prices are provided above in Table 9 for investors' reference. In the short run, the U.S stock market and Canada stock market may share a similar trend, and the Mexican stock market may be largely impacted by Canada stock market, but the U.S stock market doesn't show strong relations with the Mexico stock market.

Investors may get a reference for the trend of one country's stock market from the performance of the other stock markets. From this point to the following week, it may not be a profit-earning opportunity to invest in the North American stock markets as the major stock markets in the North American market all show a declining trend in the following week's prices. More studies could be done on this topic of forecasting and analyzing the North American stock markets. The long-term relationships among the North American stock markets aren't revealed to the investors. Forecasting models with more confidence and efficiency may be able to be applied to this topic.

References

[1]   Erkam Guresen, Gulgun Kayakutlu, Tugrul U. Daim. Using artificial neural network models in stock market index prediction. In: Expert Systems with Applications, vol. 38, Issue 8, pp. 10389-10397, ISSN 0957-4174. (2011), https://doi.org/10.1016/j.eswa.2011.02.068.Accessed Aug. 2022.

[2]   Wong, W.-K., Penm, J., Terrell, R. D., & Ching, K. Y. The Relationship between Stock Markets of Major Developed Countries and Asian Emerging Markets. In: Journal of Applied Mathematics and Decision Sciences, vol. 8, no. 4, pp.201–218. (2004), https://doi.org/10.1207/s15327612jamd0804_1. Accessed Aug. 2022.

[3]   Syriopoulos, T. Risk and return implications from investing in emerging European stock markets. In: Journal of International Financial Markets, Institutions and Money, vol. 16, no. 3, pp. 283–299 (2006), https://doi.org/10.1016/j.intfin.2005.02.005. Accessed Aug. 2022.

[4]   Clark, J., & Berko, E. Foreign investment fluctuations and emerging market stock returns: The case of mexico. SSRN Electronic Journal. (1997) https://doi.org/10.2139/ssrn.993813.

[5]   G.Peter Zhang, Time series forecasting using a hybrid ARIMA and neural network model. In:Neurocomputing,Vol. 50, pp.159-175, ISSN0925-2312 (2003), https://doi.org/10.1016/S0925-2312(01)00702-0.Accessed Aug. 2022.

[6]   S&P 500®. S&P Dow Jones Indices. (n.d.). Retrieved August 22, 2022, from https://www.spglobal.com/spdji/en/indices/equity/sp-500/#overview.

[7]   *S&P/TSX Composite index. S&P Dow Jones Indices. (n.d.). Retrieved August 22, 2022, from https://www.spglobal.com/spdji/en/indices/equity/sp-tsx-composite-index/#overview.*

[8]   *IPC Mexico Stock market2022 data - 1987-2021 historical - 2023 forecast - quote. IPC Mexico Stock Market - 2022 Data - 1987-2021 Historical - 2023 Forecast - Quote. (n.d.). Retrieved August 22, 2022, from https://tradingeconomics.com/mexico/stock-market.*

[9]   *Yahoo Finance Homepage, https://finance.yahoo.com/, last accessed 2022/8/23.*

[10] *Mader, H. M., & Nason, G. P. Stationary and non-stationary time series. In Statistics in Volcanology (pp. 129–130). essay, Geological Society. (2006).*

[11] *Palachy, S. (2019, November 12). Detecting stationarity in time series data. Medium, Towards Data Science. Retrieved August 22, 2022, from https://towardsdatascience.com/detecting-stationarity-in-time-series-data-d29e0a21e638.*

[12] *Sani, B., & Kingsman, B. G. Selecting the best periodic inventory control and demand forecasting methods for low demand items. In: Journal of the Operational Research Society,vol. 48, no. 7, pp. 700–713. (1997) https://doi.org/10.1038/sj.jors.2600418.*

[13] *Y. Zhuang, L. Chen, X. S. Wang and J. Lian, "A Weighted Moving Average-based Approach for Cleaning Sensor Data," 27th International Conference on Distributed Computing Systems (ICDCS '07), 2007, pp. 38-38, doi: 10.1109/ICDCS.2007.83.*

[14] *Aimran, A. N., & Afthanorhan, A. A comparison between single exponential smoothing (SES), double exponential smoothing (DES), Holt's (brown) and adaptive response rate exponential smoothing (arres) techniques in forecasting Malaysia population. In: Global Journal of Mathematical Analysis, vol. 2, no. 4, 2014, pp. 276–280., https://doi.org/10.14419/gjma.v2i4.3253.*

[15] *Rachmat, R., & Suhartono, S. Comparative analysis of single exponential smoothing and Holt's method for quality of hospital services forecasting in General Hospital. In: Bulletin of Computer Science and Electrical Engineering, vol. 1, no. 2, 2020, pp. 80–86. https://doi.org/10.25008/bcsee.v1i2.8.*

[16] *Chai, T., & Draxler, R. R. Root mean square error (RMSE) or mean absolute error (Mae)? – Arguments against avoiding RMSE in the literature. In: Geoscientific Model Development, vol. 7, no. 3, 2014, pp. 1247–1250., https://doi.org/10.5194/gmd-7-1247-2014.*