

Stock Closing Price Prediction Using Machine Learning

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Abstract—this research was prepared to predict the closing price of the stock in the Stock Exchange of Thailand (SET). We are using the Multi-Layer Perceptron model, Support Vector Machine model, and Partial Least Square Classifier to predict the closing price of the stock. In the present, people have more knowledge and understanding of investing in the stock market then the Thai stock market has grown significantly. From the statistical data, we can find the movement of stock prices in that stock market move in a cycle. Form this point; we have the idea that if we can predict the stock price nearby real price. We can be investing at the right time and help investors to reduce investment risks. The experimental result shows that Partial Least Square is the best algorithm of the three algorithms to predict the stock closing price.

Keywords—The Stock Exchange of Thailand (SET), stock, machine learning, Multi-Layer Perceptron (MLP), Partial Least Square (PLS), Sequential Minimal Optimization (SMO), EMA, MACD

I. INTRODUCTION

The Stock Exchange of Thailand acts as a trading center for listed securities and develop various systems necessary to facilitate the trading of securities [1]. In the present, people have more knowledge and understanding of investing in the stock market. The Thai stock market has grown significantly because many new investors are starting to invest in the Stock Exchange of Thailand (SET). Meanwhile, the variance of the stock market relating to many factors such as the number of people in the stock exchange, foreign exchange rates, economic situation, and capital flow. From the factors mentioned above, therefore, the stock market may have a high risk of investment. Investors without knowledge of the investment may cause damage to the money invested. However, from statistical data, it can be found that the movement of stock prices in that stock market moves in a cycle. At this point we have the idea that if we catch the timing signal, the movement of the stock price has been in range then we can invest at that time. [2]

For selected the timing of the stock price movement correctly. We need to be able to predict the price of the stock in the future. If we cannot predict the future price, there is no way to know when to invest. In order to predict the price of the stock in the future is possible, we use statistical analysis to help predict, because of the price of the stock itself is already a cycle. It is possible for us to catch the rhythm that, at present,

the price of the stock is within any part of the cycle. In order to know what direction the stock price go in the future.

II. PREDICTION METHODS

For selecting the algorithms, we choose 3 algorithms to test the ability to predict stock closing prices. We use the same training set and the same test set. The three algorithms such as Multi-layer Perceptron, Sequential Minimal Optimizations, and Partial Least Square.

A. Multi-Layer Perceptron (MLP)

Multi-layer Perceptron is a mathematical model that researchers use to process data based on the imitation of the human nervous system. [3] Multi-layer Perceptron is a form of artificial neural network with a multi-layered structure. The Multi-layer Perceptron used for complex tasks with good results with a supervise process and using Backpropagation for training. The Backpropagation consists of 2 sub-sections: Forward Pass and Backward Pass. In the Forward Pass, data pass through the artificial neural network into the data input layer and pass from another layer to another layer until reaching the data output layer. For Backward Pass, the connection weight value adjusted according to the value Error-Correction. Error-Correction is the difference of the actual response with the target response is an error signal that this error is sent back into the artificial neural network in the opposite direction to the connection. The weight of the connection be adjusted until the actual response approaches the target response.

Multi-layer Perceptron consists of 3 significant parts, including the input layer, the hidden layer, the output layer. The input layer is the layer that is used to enter the data that we want to analyze into the input layer. The data in the input layer is forward to the hidden layer. The hidden layers try to convert the data into that layer to be linearly separable before the data sent to the output layer. In the final step, the Hidden layer data must be linearly separable. It may need to use a hidden layer of more than 1 layer to convert the data into a linearly separable form. The activation function of each layer is not necessarily a thresholding function and does not need to be the same function.

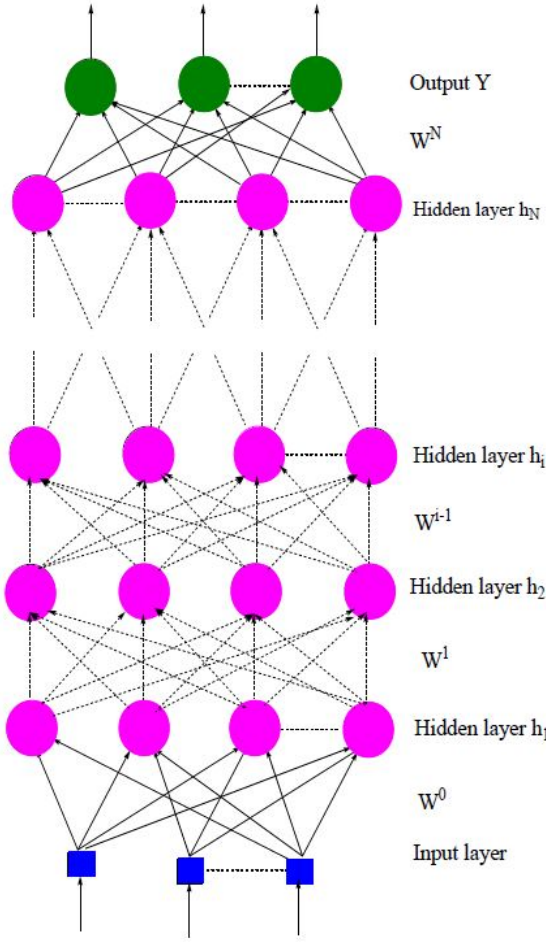


Figure 1. Multi-Layer Perceptron Model. [3]

B. Sequential Minimal Optimization (SMO)

Sequential Minimal Optimization Algorithm is an effective method for training Support Vector Machines (SVMs) on classification tasks as well as regression problems. [4] Support Vector Machines are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. The SVMs models generate the regress function by applying a set of high dimensional linear functions. The SVMs are employing to estimate the nonlinear behavior of the forecasting data set because Gaussian kernels tend to give excellent performance under general smoothness assumptions.

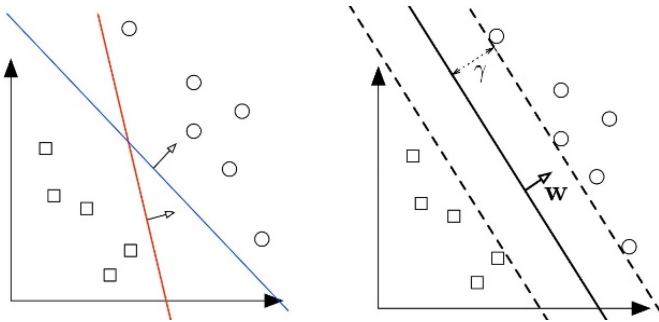


Figure 2. Support Vector Machine Model.[5]

Creating an SVM model selects the linear model that has the best margin distance. It does not choose a linear model that is too close to each vector because it may cause overfitting. If there are new data that are too close together, it makes the predictions error. There are many advantages of SVM, such as the kernel function that can change the dimension of the data to a higher dimension.

C. Partial Least Square (PLS)

Partial Least Squares Method is a method for analyzing multiple data in the creation of a relationship model between the observed population groups using the latent variable. [6] PLS has used algorithms in Management of Path Modeling Problems in Economics.

PLS is a method for analyzing data that has received much attention from statisticians and researchers because PLS is able to handle vast amounts of data at the moment with a minimal sample size.

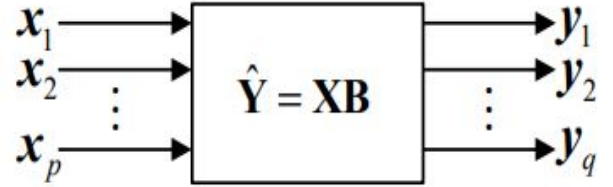


Figure 3. Partial Least Square Model. [7]

Partial Least Square was used to find the relationship between the two-dimension X and Y. The PLS model attempts to find a multi-dimensional direction in the X area, which explains the maximum multi-dimensional variance in the Y area. PLS is especially suitable when the matrix of the predictor has more variables than observation, and when there are many correlations between the X values.

Partial Least Square is one of the Regression techniques. Initially, the Partial Least Square was developed to be able to deal with the problem of regression analysis in the creation of Chemometrics and Spectrometric variables. In the present, Partial Least Square has attracted many statisticians as PLS can handle large amounts of data while there are very few examples. It makes PLS more flexible and able to solve many problems.

III. RESEARCH METHODOLOGY

This research is designed to test the ability to predict stocks. We are using the same training set. We use three algorithms to test the predictability of Multi-layer Perceptron (MLP), sequential minimal optimization algorithm (SMO), and Partial Least Squares Classifier (PLS Classifier).

A. Data Preparation

1) *Data Selection:* In this research, we focus on the trials of 50 stocks form SET50. [8] Therefore, we have to pull out the data of all 50 stocks first. By starting, we have brought the information directly from the Stock Exchange of Thailand (SET) website, which has information on every stock price

that is in the stock market for the past 1 year. We use 100 stocks in the SET100 that do not use the stock in the same duration of a test set. After we get 100 stocks, we combined all 100 stocks for creating the 1 training set. [9]

The raw data format that we have obtained is as follow:

Date	Open	High	Low	Close	Change	%Change	Total Volume (Shares)	Total Value ('000 Baht)
01-12-58	170.00	171.00	169.00	169.00	-2.00	-1.17	3526309.00	599361.48
02-12-58	169.00	171.00	166.00	167.00	-2.00	-1.18	9279658.00	1566102.67
03-12-58	166.00	168.50	166.00	167.00	0.00	0.00	6771799.00	1131959.40
04-12-58	167.00	168.00	166.00	166.00	-1.00	-0.60	11265959.00	1877607.03
08-12-58	165.00	165.50	160.50	160.50	-5.50	-3.31	10213926.00	1657496.39
09-12-58	161.00	161.50	157.00	157.50	-3.00	-1.87	12700080.00	2022292.17
11-12-58	157.00	157.50	153.00	153.50	-4.00	-2.54	8367550.00	1295804.04
14-12-58	150.50	153.00	149.00	152.00	-1.50	-0.98	12570140.00	1896549.39
15-12-58	152.50	154.50	150.50	154.50	2.50	1.64	14404084.00	2201190.99
16-12-58	155.50	157.00	153.50	154.00	-0.50	-0.32	12677956.00	1966075.46
17-12-58	154.00	155.00	153.00	153.00	-1.00	-0.65	21074299.00	3240618.53
18-12-58	152.00	152.50	149.50	150.50	-2.50	-1.63	16811211.00	2536501.04
21-12-58	149.00	152.50	149.00	151.50	1.00	0.66	12697692.00	1920959.48
22-12-58	152.00	153.00	147.00	147.00	-4.50	-2.97	11111842.00	1655141.72
23-12-58	148.00	151.00	148.00	151.00	4.00	2.72	6679497.00	999145.15
24-12-58	152.50	153.00	151.00	151.50	0.50	0.33	4646879.00	704948.30
25-12-58	151.50	152.00	150.00	150.50	-1.00	-0.66	2394769.00	360789.03
28-12-58	151.00	153.50	151.00	152.50	2.00	1.33	4259984.00	649533.03
29-12-58	152.00	152.00	151.00	151.00	-1.50	-0.98	4007675.00	607170.89
30-12-58	152.00	152.50	150.50	150.50	-0.50	-0.33	22749168.00	3436814.43
04-01-59	150.00	150.00	146.00	147.50	-3.00	-1.99	8014150.00	1183980.07
05-01-59	147.50	148.00	145.00	146.00	-1.50	-1.02	8318354.00	1215149.05
06-01-59	146.00	149.00	145.50	148.00	2.00	1.37	5618840.00	828625.22
07-01-59	145.50	146.50	144.00	144.00	-4.00	-2.70	8934136.00	1296899.06
08-01-59	145.00	147.00	145.00	146.50	2.50	1.74	6500285.00	949406.39
11-01-59	145.00	147.50	144.00	147.50	1.00	0.68	8982753.00	1305931.61
12-01-59	148.50	155.00	148.50	154.50	7.00	4.75	14792147.00	2252074.02
13-01-59	158.00	163.00	157.00	163.00	8.50	5.50	22677857.00	3641258.36
14-01-59	160.50	162.50	159.50	159.50	-3.50	-2.15	12313394.00	1980970.47

Figure 4. Raw data from the Stock Exchange of Thailand.

2) *Data Cleaning*: When we have collected the data, we have to check that the data collected have missing data or not have missing data. For example, it may be due to the fact that the stock has an unusual price movement. Causing the SET to prohibit the trading of that stock on that day or maybe banned for sale the next day, causing the gap of stock price data. We, therefore, need to fill that gap. The method used to fill the gap is to use the average value during the day that the data is missing. After we check the missing value, we proceed to the next step.

3) *Data Reduction*: After we have finished checking the data, we will use 3 attributes of the data to be used were the highest price, the lowest price, and the closing price. We use only 3 attributes because of:

a) In this research, we focus on the closing price. We do not want the opening price, and we have arranged the data by date, then the date attribute is not required to be used again.

b) Attribute change value and percent change; it a value that tells us is how much today price different from yesterday's price. We have the closing price that arranged by the date. We do not want these attributes in this work.

c) In the attribute, the number of shares traded (stock volume). In this experiment, we focus on the combined model creating from SET100. The model can use to predict every

stock. That means we cannot use attributes volume in our research because each of the stocks has a different volume. The amount of shares traded daily is also different too.

d) In the total price value, because each stock price and the volume of each stock are different, therefore not be necessary to use in this work.

4) *Data Transformation*: After we select 3 attributes, We use these 3 attributes to create other attributes by using the equation to create additional information. Additional attributes that we need are as follows.

a) *Pivot Point*: Pivot is the average of the day calculated from the average of the highest price, the lowest price, and the closing price. [10] Pivot Point can calculate form following formula:

$$\text{Pivot} = \frac{\text{High} + \text{Low} + \text{Close}}{3} \quad (1)$$

High is the highestprice of the day. Low is the lowest price of the day. Close is the closing price of the day.

b) *Moving Average*: Moving average is a calculation of the average price of a stock in a certain period of time. A Moving average that we use is EMA (Exponential Moving Average) [11] following formula:

$$\text{EMA} = [\text{MA} (n-1) + \text{SF} (\text{Pn} - \text{EMA} (n-1))]. \quad (2)$$

MA is a simple moving average, n is a number of days to calculate, Pn is the closing price of that day, and SF is a Smoothing Factor following formula:

$$\text{SF} = 2 / (n+1). \quad (3)$$

c) *MACD (Moving Average with Convergence Divergence)*: MACD is used to measure the distance between the Short-term EMA and Long-term EMA to see if the Short-term value is greater than the Long-term value result is a positive value. [12] If the Long-term value is greater than the Short-term value result is a negative value. If the MACD value of the current day is greater than yesterday's value, indicating that the volume is increasing. On the other hand, if the MACD value of the present day is less than yesterday's value, indicating that trading volume has decreased. The formula for finding values is as follows.

$$\text{MACD} = \text{EMA} (\text{Short}) - \text{EMA} (\text{Long}). \quad (4)$$

Short and long means the day that we select to use for calculated. In the standard of MACD, EMA calculated from 12 and 26 days, but if the investor has a trading style that buys quickly, sells quickly, or the period of shares is not long, then can adjust the number of days to a shakedown. In this research, we use 5 and 25 days because we want to predict the short-term closing price. We, therefore, need to choose the least number of days. Then we choose 5 days from the shortest short term and select 25 days from the shortest medium term.

The number of days is the primary day for investors used. In the short term, they are using 5,10,15,20 days. For the medium term, they are using 25,30,50,75 days, and in the long term, they are using 100,200 and 400 days.

d) *Signal line* : Signal Line is an Exponential Moving Average of MACD. The purpose of the Signal Line line is to specify that the MACD is likely to be an upward trend or downward trend. If the MACD value is greater than the Signal line value, then the MACD is likely to be an upward trend. On the other hand, if the MACD value is less than the Signal line value, the MACD is likely to be a downward trend. The formula for finding values is as follows.

$$\text{Signal line} = \text{EMA}(\text{MACD}) \quad (5)$$

Signal line in this research is calculated from EMA of 10 day MACD data.

5) *Data Integration*: After we convert the data into many attributes, then we have to bring each attribute to add as a set of data and assign a class for analysis. In the data section of the training set for creating the model, we have to combine the data of all 100 stocks from SET100 into one set. To do this, we need to follow the steps of the Data Preparation as well as preparing data for the test set as well.

6) *Evaluation*: When we get the prediction result to compare which algorithms can predict stock closing price precision. We use Mean Absolute Error (MAE) [13] to test the algorithms, the MAE equation as follows:

$$\text{MAE} = \frac{1}{N} \sum_{i=0}^N |\bar{y}_i - y_i|. \quad (6)$$

We use Price Level Error (PLE) to test the algorithms, the PLE equation as follows:

$$\text{PLE} = \frac{\text{MAE}}{\text{MPL}}. \quad (7)$$

MPL is a Market Price Level. [14]

B. Algorithm for prediction

This research uses the Multi-Layer Perceptron (MLP) and Sequential Minimal Optimization (SMO) Module of the Weka program in data classification [15] by setting the parameters as follows.

1) *Multi-Layer Perceptron (MLP)*: To create an MLP model, we define a hidden layer equal to the number of all attributes and class. Give the learning rate at 0.3, let the momentum be 0.2 and let training time at 500, which is the basic value for classification. Creating a model, we train with cross-validation use the folds at 10.

2) *Sequential Minimal Optimization (SMO)*: In the creation of the SMO model, we configure the kernel as a Polynomial Kernel, which is the basic kernel for data classification and requires the Filter Type to be normalized.

3) *Partial Least Squares Classifier (PLS Classifier)*: To create the PLS model, we utilizing the PLS Filter's ability to perform predictions.

IV. EXPERIMENT AND RESULT

We create models using training data based on 100 stock data from SET100. We combine all 100 stock data to creating 1 training set. For combining the stock data, we sort stocks with similar prices. If there was a gap between the stock prices, we must fill that gap first. For example, shares A, the final price is 20 baht, and shares B, the final price is 25 baht. According to the Market Price Level principle, at this price level, the share price increase or decrease by 0.1 baht per level. We must start to fill the missing data between both. For the first, we must average the price between both shares prices and added the data by sort the prices from those 2 shares. The price that increases or decreases per price level must more than 0.1 baht per price level. The price added must increase or decrease not higher than 30% of the yesterday price according to the rules of the Stock Exchange of Thailand (SET). We have 31 attributes such as Close Price 5 attributes, Pivot 5 attributes, EMA (5) 5 attributes, EMA (25) 5 attributes, MACD 5 attributes, Signal line 5 attributes, and class 1 attributes.

A1	A2	Dim1	Dim2	Dim3	Dim4	Dim5	Dim6	Dim7	Dim8	Dim9	Dim10	Dim11	Dim12	Dim13	Dim14	Dim15	Dim16	Dim17	Dim18	Dim19	Dim20	Dim21	Dim22	Dim23	Dim24	Dim25	Dim26	Dim27	Dim28	Dim29	Dim30	Dim31	Dim32	Dim33	Dim34	Dim35	Dim36	Dim37	Dim38	Dim39	Dim40	Dim41	Dim42	Dim43	Dim44	Dim45	Dim46	Dim47	Dim48	Dim49	Dim50	Dim51	Dim52	Dim53	Dim54	Dim55	Dim56	Dim57	Dim58	Dim59	Dim60	Dim61	Dim62	Dim63	Dim64	Dim65	Dim66	Dim67	Dim68	Dim69	Dim70	Dim71	Dim72	Dim73	Dim74	Dim75	Dim76	Dim77	Dim78	Dim79	Dim80	Dim81	Dim82	Dim83	Dim84	Dim85	Dim86	Dim87	Dim88	Dim89	Dim90	Dim91	Dim92	Dim93	Dim94	Dim95	Dim96	Dim97	Dim98	Dim99	Dim100	Dim101	Dim102	Dim103	Dim104	Dim105	Dim106	Dim107	Dim108	Dim109	Dim110	Dim111	Dim112	Dim113	Dim114	Dim115	Dim116	Dim117	Dim118	Dim119	Dim120	Dim121	Dim122	Dim123	Dim124	Dim125	Dim126	Dim127	Dim128	Dim129	Dim130	Dim131	Dim132	Dim133	Dim134	Dim135	Dim136	Dim137	Dim138	Dim139	Dim140	Dim141	Dim142	Dim143	Dim144	Dim145	Dim146	Dim147	Dim148	Dim149	Dim150	Dim151	Dim152	Dim153	Dim154	Dim155	Dim156	Dim157	Dim158	Dim159	Dim160	Dim161	Dim162	Dim163	Dim164	Dim165	Dim166	Dim167	Dim168	Dim169	Dim170	Dim171	Dim172	Dim173	Dim174	Dim175	Dim176	Dim177	Dim178	Dim179	Dim180	Dim181	Dim182	Dim183	Dim184	Dim185	Dim186	Dim187	Dim188	Dim189	Dim190	Dim191	Dim192	Dim193	Dim194	Dim195	Dim196	Dim197	Dim198	Dim199	Dim200	Dim201	Dim202	Dim203	Dim204	Dim205	Dim206	Dim207	Dim208	Dim209	Dim210	Dim211	Dim212	Dim213	Dim214	Dim215	Dim216	Dim217	Dim218	Dim219	Dim220	Dim221	Dim222	Dim223	Dim224	Dim225	Dim226	Dim227	Dim228	Dim229	Dim230	Dim231	Dim232	Dim233	Dim234	Dim235	Dim236	Dim237	Dim238	Dim239	Dim240	Dim241	Dim242	Dim243	Dim244	Dim245	Dim246	Dim247	Dim248	Dim249	Dim250	Dim251	Dim252	Dim253	Dim254	Dim255	Dim256	Dim257	Dim258	Dim259	Dim260	Dim261	Dim262	Dim263	Dim264	Dim265	Dim266	Dim267	Dim268	Dim269	Dim270	Dim271	Dim272	Dim273	Dim274	Dim275	Dim276	Dim277	Dim278	Dim279	Dim280	Dim281	Dim282	Dim283	Dim284	Dim285	Dim286	Dim287	Dim288	Dim289	Dim290	Dim291	Dim292	Dim293	Dim294	Dim295	Dim296	Dim297	Dim298	Dim299	Dim300	Dim301	Dim302	Dim303	Dim304	Dim305	Dim306	Dim307	Dim308	Dim309	Dim310	Dim311	Dim312	Dim313	Dim314	Dim315	Dim316	Dim317	Dim318	Dim319	Dim320	Dim321	Dim322	Dim323	Dim324	Dim325	Dim326	Dim327	Dim328	Dim329	Dim330	Dim331	Dim332	Dim333	Dim334	Dim335	Dim336	Dim337	Dim338	Dim339	Dim340	Dim341	Dim342	Dim343	Dim344	Dim345	Dim346	Dim347	Dim348	Dim349	Dim350	Dim351	Dim352	Dim353	Dim354	Dim355	Dim356	Dim357	Dim358	Dim359	Dim360	Dim361	Dim362	Dim363	Dim364	Dim365	Dim366	Dim367	Dim368	Dim369	Dim370	Dim371	Dim372	Dim373	Dim374	Dim375	Dim376	Dim377	Dim378	Dim379	Dim380	Dim381	Dim382	Dim383	Dim384	Dim385	Dim386	Dim387	Dim388	Dim389	Dim390	Dim391	Dim392	Dim393	Dim394	Dim395	Dim396	Dim397	Dim398	Dim399	Dim400	Dim401	Dim402	Dim403	Dim404	Dim405	Dim406	Dim407	Dim408	Dim409	Dim410	Dim411	Dim412	Dim413	Dim414	Dim415	Dim416	Dim417	Dim418	Dim419	Dim420	Dim421	Dim422	Dim423	Dim424	Dim425	Dim426	Dim427	Dim428	Dim429	Dim430	Dim431	Dim432	Dim433	Dim434	Dim435	Dim436	Dim437	Dim438	Dim439	Dim440	Dim441	Dim442	Dim443	Dim444	Dim445	Dim446	Dim447	Dim448	Dim449	Dim450	Dim451	Dim452	Dim453	Dim454	Dim455	Dim456	Dim457	Dim458	Dim459	Dim460	Dim461	Dim462	Dim463	Dim464	Dim465	Dim466	Dim467	Dim468	Dim469	Dim470	Dim471	Dim472	Dim473	Dim474	Dim475	Dim476	Dim477	Dim478	Dim479	Dim480	Dim481	Dim482	Dim483	Dim484	Dim485	Dim486	Dim487	Dim488	Dim489	Dim490	Dim491	Dim492	Dim493	Dim494	Dim495	Dim496	Dim497	Dim498	Dim499	Dim500	Dim501	Dim502	Dim503	Dim504	Dim505	Dim506	Dim507	Dim508	Dim509	Dim510	Dim511	Dim512	Dim513	Dim514	Dim515	Dim516	Dim517	Dim518	Dim519	Dim520	Dim521	Dim522	Dim523	Dim524	Dim525	Dim526	Dim527	Dim528	Dim529	Dim530	Dim531	Dim532	Dim533	Dim534	Dim535	Dim536	Dim537	Dim538	Dim539	Dim540	Dim541	Dim542	Dim543	Dim544	Dim545	Dim546	Dim547	Dim548	Dim549	Dim550	Dim551	Dim552	Dim553	Dim554	Dim555	Dim556	Dim557	Dim558	Dim559	Dim560	Dim561	Dim562	Dim563	Dim564	Dim565	Dim566	Dim567	Dim568	Dim569	Dim570	Dim571	Dim572	Dim573	Dim574	Dim575	Dim576	Dim577	Dim578	Dim579	Dim580	Dim581	Dim582	Dim583	Dim584	Dim585	Dim586	Dim587	Dim588	Dim589	Dim590	Dim591	Dim592	Dim593	Dim594	Dim595	Dim596	Dim597	Dim598	Dim599	Dim600	Dim601	Dim602	Dim603	Dim604	Dim605	Dim606	Dim607	Dim608	Dim609	Dim610	Dim611	Dim612	Dim613	Dim614	Dim615	Dim616	Dim617	Dim618	Dim619	Dim620	Dim621	Dim622	Dim623	Dim624	Dim625	Dim626	Dim627	Dim628	Dim629	Dim630	Dim631	Dim632	Dim633	Dim634	Dim635	Dim636	Dim637	Dim638	Dim639	Dim640	Dim641	Dim642	Dim643	Dim644	Dim645	Dim646	Dim647	Dim648	Dim649	Dim650	Dim651	Dim652	Dim653	Dim654	Dim655	Dim656	Dim657	Dim658	Dim659	Dim660	Dim661	Dim662	Dim663	Dim664	Dim665	Dim666	Dim667	Dim668	Dim669	Dim670	Dim671	Dim672	Dim673	Dim674	Dim675	Dim676	Dim677	Dim678	Dim679	Dim680	Dim681	Dim682	Dim683	Dim684	Dim685	Dim686	Dim687	Dim688	Dim689	Dim690	Dim691	Dim692	Dim693	Dim694	Dim695	Dim696	Dim697	Dim698	Dim699	Dim700	Dim701	Dim702	Dim703	Dim704	Dim705	Dim706	Dim707	Dim708	Dim709	Dim710	Dim711	Dim712	Dim713	Dim714	Dim715	Dim716	Dim717	Dim718	Dim719	Dim720	Dim721	Dim722	Dim723	Dim724	Dim725	Dim726	Dim727	Dim728	Dim729	Dim730	Dim731	Dim732	Dim733	Dim734	Dim735	Dim736	Dim737	Dim738	Dim739	Dim740	Dim741	Dim742	Dim743	Dim744	Dim745	Dim746	Dim747	Dim748	Dim749	Dim750	Dim751	Dim752	Dim753	Dim754	Dim755	Dim756	Dim757	Dim758	Dim759	Dim760	Dim761	Dim762	Dim763	Dim764	Dim765	Dim766	Dim767	Dim768	Dim769	Dim770	Dim771	Dim772	Dim773	Dim774	Dim775	Dim776	Dim777	Dim778	Dim779	Dim780	Dim781	Dim782	Dim783	Dim784	Dim785	Dim786	Dim787	Dim788	Dim789	Dim790	Dim791	Dim792	Dim793	Dim794	Dim795	Dim796	Dim797	Dim798	Dim799	Dim800	Dim801	Dim802	Dim803	Dim804	Dim805	Dim806	Dim807	Dim808	Dim809	Dim810	Dim811	Dim812	Dim813	Dim814	Dim815	Dim816	Dim817	Dim818	Dim819	Dim820	Dim821	Dim822	Dim823	Dim824	Dim825	Dim826	Dim827	Dim828	Dim829	Dim830	Dim831	Dim832	Dim833	Dim834	Dim835	Dim836	Dim837	Dim838	Dim839	Dim840	Dim841	Dim842	Dim843	Dim844	Dim845	Dim846	Dim847	Dim848	Dim849	Dim850	Dim851	Dim852	Dim853	Dim854	Dim855	Dim856	Dim857	Dim858	Dim859	Dim860	Dim861	Dim862	Dim863	Dim864	Dim865	Dim866	Dim867	Dim868	Dim869	Dim870	Dim871	Dim872	Dim873	Dim874	Dim875	Dim876	Dim877	Dim878	Dim879	Dim880	Dim881	Dim882	Dim883	Dim884	Dim885	Dim886	Dim887	Dim888	Dim889	Dim890	Dim891	Dim892	Dim893	Dim894	Dim895	Dim896	Dim897	Dim898	Dim899	Dim900	Dim901	Dim902	Dim903	Dim904	Dim905	Dim906	Dim907	Dim908	Dim909	Dim910	Dim911	Dim912	Dim913	Dim914	Dim915	Dim916	Dim917	Dim918	Dim919	Dim920	Dim921	Dim922	Dim923	Dim924	Dim925	Dim926	Dim927	Dim928	Dim929	Dim930	Dim931	Dim932	Dim933	Dim934	Dim935	Dim936	Dim937	Dim938	Dim939	Dim940	Dim941	Dim942	Dim943	Dim944	Dim945	Dim946	Dim947	Dim948	Dim949	Dim950	Dim951	Dim952	Dim953	Dim954	Dim955	Dim956	Dim957	Dim958	Dim959	Dim960	Dim961	Dim962	Dim963	Dim964	Dim965	Dim966	Dim967	Dim968	Dim969	Dim970	Dim971	Dim972	Dim973	Dim974	Dim975	Dim976	Dim977	Dim978	Dim979	Dim980	Dim981	Dim982	Dim983	Dim984	Dim985	Dim986	Dim987	Dim988	Dim989	Dim990	Dim991	Dim992	Dim993	Dim994	Dim995	Dim996	Dim997	Dim998	Dim999	Dim1000
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Figure 5. Data for training.

We have 16,922 data for training from SET100, all of 100 stock duration 1 year. After we had received the training set, we create a test set based on 50 stocks from SET50, with 1 stock having 1 test set. In summary, we have 50 test set after we have prepared the data. In the 1 test set, we have 295 data duration for 1 year. We created a model by using a training set with 3 algorithms and get 3 models. After that, we test all 50 test sets with 3 models. Therefore, we get 150 experiment results.

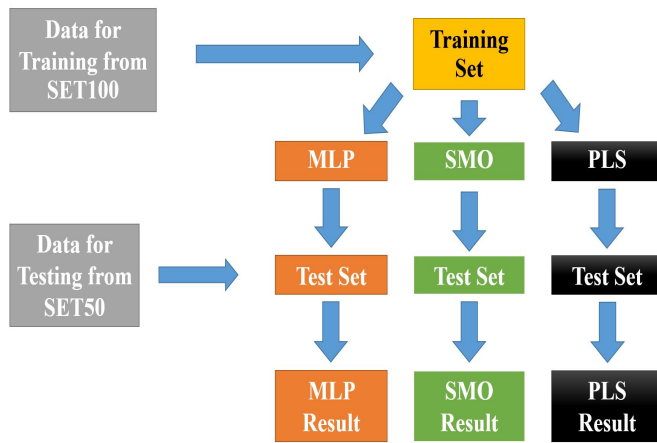


Figure 6. data for training from SET100 and data for testing from SET50.

In the Stock Exchange of Thailand (SET), it has a Market Price Level (MPL). Market Price Level is a Minimum price movement, as prescribed by the SET for securities trading, vary according to each market price level. If we want to know our predictions on how much the error value in the price level is different. We need to calculate the stock price level according to the following in TABLE I.

TABLE I. MARKET PRICE LEVEL

Market Price Level (THB)	Tick sizes (THB) (effective since March 30, 2009)
Less than 2	0.01
2 up to less than 5	0.02
5 up to less than 10	0.05
10 up to less than 25	0.10
25 up to less than 100	0.25
100 up to less than 200	0.50
200 up to less than 400	1.00
400 up	2.00

From the TABLE I., It shows that the price range of each stock is an uneven price movement. The price range change according to the market price level. Therefore we have to divide the price level from the MAE value that can let us know the stock Price Level Error (PLE) how much changed.

	Bid		Offer	
Current Price	4,358,000	2.00	2.02	11,158,000
1 PLE Error	6,151,000	1.99	2.04	22,171,000
2 PLE Error	3,112,000	1.98	2.06	24,310,400
3 PLE Error	7,858,200	1.97	2.08	23,333,100
	4,275,000	1.96	2.10	32,553,000
Sell Vol	38,838,700			28.06%

Figure 7. Bid and Offer, Bid for the people who want to buy stock and Offer for people who want to sell stock.

From the figure 7 shows that the current price is equal to 2 baht. If the stock price increases and greater than 2 baht, there be tick sizes at 0.02 baht per level, resulting in the price increase to be 2.02, 2.04, 2.06 baht, respectively. On the other hand, if the stock's price decreases and less than 2 baht, there be tick sizes at 0.01 baht per level, resulting in the price decreasing to be 1.99, 1.98, 1.97 baht, respectively. At this point, we use the Price Level Error to show how many deviations from the current price. For example, if the result of the error value is 3 PLE, then the possible price error of that stock be graded from 1.97, 1.98, 1.99, 2.00, 2.02, 2.04, and 2.06. The results of the Prediction shown in TABLE II.

TABLE II. PREDICTION RESULTS

Stock Name	SMO		MLP		PLS		Price Level
	MAE	PLE	MAE	PLE	MAE	PLE	
ADVANC	1.91	3.81	1.90	3.81	2.00	4.00	0.50
AOT	0.57	2.28	0.64	2.58	0.59	2.37	0.25
BA	0.31	1.22	0.30	1.21	0.31	1.23	0.25
BANPU	0.34	3.41	0.32	3.20	0.35	3.49	0.10
BBL	1.69	1.69	1.74	1.74	1.78	1.78	1.00
BCP	0.42	1.67	0.43	1.72	0.42	1.67	0.25
BDMS	0.22	0.87	0.21	0.86	0.21	0.84	0.25
BEC	0.36	1.44	0.35	1.40	0.35	1.42	0.25
BEM	0.14	1.42	0.17	1.74	0.10	1.03	0.10
BH	2.23	4.47	2.22	4.45	2.26	4.52	0.50
BLA	0.65	2.58	0.67	2.69	0.66	2.63	0.25
BTS	0.12	1.23	0.13	1.27	0.08	0.78	0.10
CBG	1.10	4.41	1.13	4.52	1.18	4.71	0.25
CENTEL	0.53	2.13	0.53	2.13	0.55	2.20	0.25
CK	0.39	1.57	0.40	1.60	0.40	1.59	0.25
CPALL	0.61	2.43	0.65	2.59	0.61	2.44	0.25
CPF	0.46	1.82	0.47	1.86	0.46	1.86	0.25
CPN	0.66	2.65	0.72	2.89	0.69	2.75	0.25
DELTA	1.21	4.83	1.25	5.02	1.25	4.98	0.25
DTAC	0.92	3.69	0.92	3.68	0.93	3.70	0.25
EGCO	1.66	1.66	1.76	1.76	1.69	1.69	1.00
GLOW	0.80	3.20	0.87	3.49	0.85	3.41	0.25
HMPRO	0.16	1.62	0.16	1.59	0.15	1.49	0.10
INTUCH	0.60	2.40	0.66	2.63	0.63	2.51	0.25
IRPC	0.12	2.39	0.20	4.05	0.07	1.31	0.05
ITD	0.14	2.76	0.19	3.84	0.09	1.74	0.05
IVL	0.56	2.25	0.57	2.29	0.57	2.28	0.25
JAS	0.16	3.29	0.21	4.17	0.13	2.69	0.05
KBANK	2.21	4.42	2.24	4.48	2.32	4.64	0.50
KTB	0.20	1.97	0.18	1.83	0.19	1.89	0.10
LH	0.15	1.46	0.14	1.42	0.11	1.14	0.10
M	0.49	1.97	0.58	2.31	0.51	2.05	0.25
MINT	0.48	1.92	0.52	2.06	0.48	1.91	0.25
PTT	4.26	2.13	4.30	2.15	4.46	2.23	2.00
PTTEP	1.24	2.49	1.29	2.58	1.29	2.58	0.50
PTTGC	0.89	3.57	0.92	3.68	0.94	3.77	0.25
ROBIN	0.87	3.49	0.92	3.69	0.92	3.69	0.25
SAWAD	0.67	2.70	0.68	2.73	0.69	2.76	0.25
SCB	1.72	3.44	1.80	3.59	1.76	3.53	0.50
SCC	4.64	2.32	4.87	2.44	4.88	2.44	2.00
SPRC	0.21	2.10	0.19	1.93	0.20	2.00	0.10
TASCO	0.50	2.00	0.48	1.91	0.51	2.05	0.25
TCAP	0.45	1.81	0.51	2.04	0.47	1.86	0.25
TMB	0.11	5.68	0.26	13.14	0.04	2.04	0.02
TOP	0.90	3.60	0.95	3.79	0.92	3.70	0.25
TPIPL	0.11	5.70	0.26	13.00	0.05	2.46	0.02
TTW	0.13	1.29	0.11	1.10	0.10	0.95	0.10
TU	0.24	2.41	0.24	2.42	0.24	2.39	0.10
WHA	0.12	5.86	0.24	12.17	0.05	2.69	0.02
TRUE	0.16	3.25	0.19	3.78	0.13	2.52	0.05
Average	0.80	2.70	0.83	3.26	0.81	2.45	0.32

From TABLE II. Mean Absolute Error Results are calculated from 1 year (295 days) historical data.

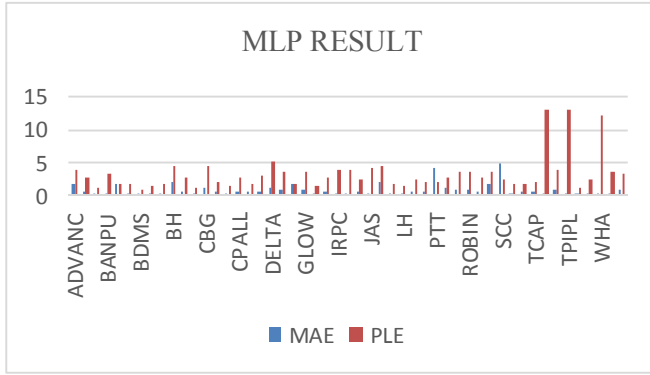


Figure 8. Mean Absolute Error and Price Level Error of Multi-Layer Perceptron results.

1) *Multi-layer Perceptron (MLP)*: Multilayer Perceptron has an average error value of 0.83376, which is considered the average error value of the highest MAE of three algorithms.

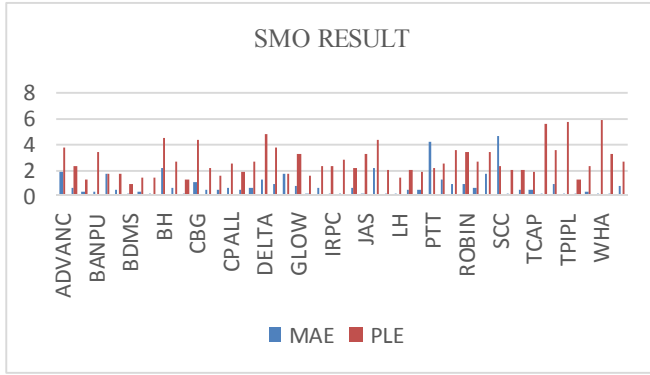


Figure 9. Mean Absolute Error and Price Level Error of Sequential Minimal Optimization results.

2) *sequential minimal optimization (SMO)*: Sequential Minimal Optimization has an average error of 0.79656, which is considered the least average MAE error value of three algorithms.

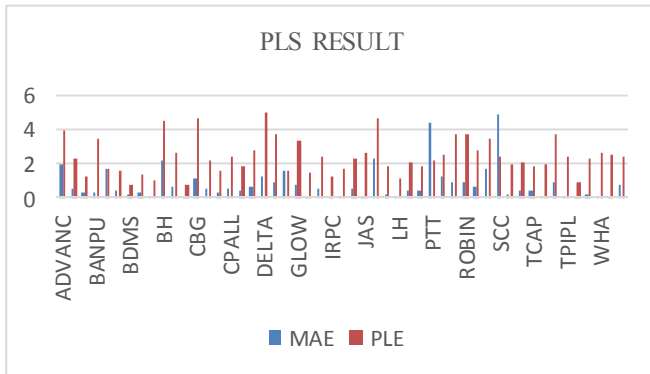


Figure 10. Mean Absolute Error and Price Level Error of Partial Least Square results.

3) *Partial Least Squares Classifier (PLS Classifier)*: The Partial Least Square has an average error of 0.81225, which is considered to be less average MAE error value which is ranked 2nd among 3 algorithms.

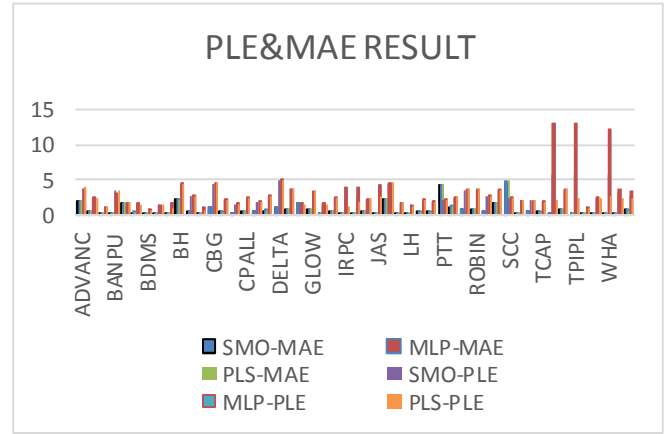


Figure 11. Mean Absolute Error and Price Level Error of three algorithm results.

From Figure. 11, it can see that the result of the Mean Absolute Error from all 3 algorithms shows that the model from SMO gives the least error result. However, if look at the format of the output from the picture shows that the movement of the MAE value from all 3 algorithms moving in a similar direction and tendency.

As for the Price Level Error, show that MLP and SMO have a certain period of very high error values. If we look at the Market Price Level of stocks during the period of high error, it shows that most of them are low-priced stocks with a Market Price Level of only 0.02 baht per level. It shows that MLP and SMO are less able to predict stock with low price range accurately, but PLS does much better in predicting stocks of all price ranges.

V. CONCLUSIONS

This research was prepared to predict the stock closing price of the next day. For helping reduce the investment risk of investors in the Stock Exchange of Thailand (SET). We selected Multi-Layer Perceptron (MLP), Sequential Minimal Optimization (SMO), and Partial Least Square (PLS) algorithms to compare predictive ability. In choosing the appropriate algorithm, we use the error value method to compare the algorithms, such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE). The error values that weka displayed have many values. However, the main thing that we are most interested in is the Mean Absolute Error. The Mean Absolute Error can tell us how much the stock closing price predicted different from the actual stock closing price. After we get the MAE value. We applied the MAE value to create the Price Level Error.

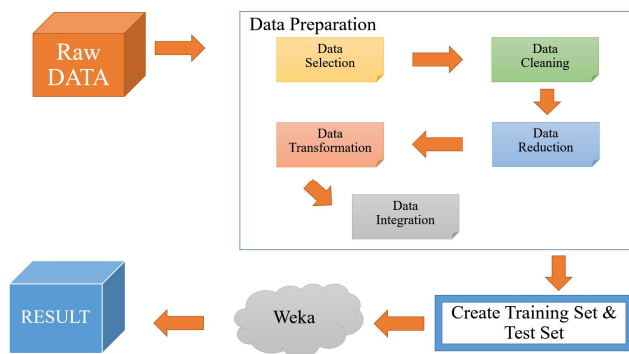


Figure 12. Methodology show that Data Preparation Method.

For the method, we bring the raw data that is the data of the daily stock price — for the first Data Preparation, starting with the Data Selection. We use the stock information from SET100 as a training set and use the data from SET50 as a test set. After that, we start Data Cleaning. Sometimes there are many factors that cause the stock price information to be missing some days. If the stock price has missing data, we must fill that gap before doing the next step. Next, we make a Data Reduction eliminate attributes that are not required or not useful. When we have the only selected attributes, we do the Data Transformation to add the required attributes such as MACD, EMA. Once the desired attributes added, we do Data Integration to include all the attributes arranged to prepare the data to be tested.

The result of prediction by WEKA found that the algorithm it gave the least average error was Sequential Minimal Optimization however when we compare the result of prediction with the stock price level shows that Partial Least Square gives the lowest average error per level.

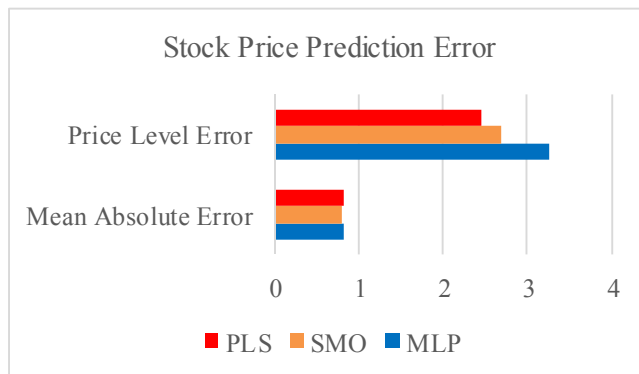


Figure 13. Stock price prediction error results.

By summarizing the results of sorting form ascending as follows:

Price Level Error sort by the least error value.

1. Partial Least Square
2. Sequential Minimal Optimization
3. Multilayer Perceptron

Mean Absolute Error sort by the least error value.

1. Sequential Minimal Optimization
2. Partial Least Square
3. Multilayer Perceptron

For investors, this research can be used to help reduce investment risk by looking at the error value in the stock closing price movement. It is appropriate to invest or not to be invest. This research may help in deciding when to buy the stock on that day. For example, if the predicted value of the closing price is 2 baht. The investor can look at that if the price has gone down to less than 2 baht or it more expensive than 2 baht. The investor should be buying the stock more or do not buy it more.

Based on the results of this experiment, we have seen that when we create a model from the 100 stock price of the SET100 can be used to predict the stock price of all 50 stocks in the SET50, indicating that overall the major stock price have trend and pattern movements that can be used to predict each other.

For future work, we hope that this work can be developed to predict the stock price in the long term. The investor can try using another indicator to test more, such as RSI or stochastic oscillator. To help investors make long-term investment decisions and reduce investor risk.

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