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Predictive Value of Candlestick Type on Price Movements in Stock Markets

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Abstract: Movements of prices in stock markets during a single trading day are typically visualized using candlestick charts, and technical analysis of the market are based on patterns found in time series of these candlesticks. Candlesticks have three parts which reflects the opening, closing, highest, and lowest prices during the trading day. The body, which describes the difference between opening and closing price, is colored light if closing is higher than opening, and dark otherwise. The upper shadow has a length equal to the distance of the highest price of the day from the upper edge of the body. The lower shadow reflects the distance of the lowest price from the lower edge of the body. Candlesticks may be classified according to the relative sizes of the body and the shadows, and the body color. In this paper, we looked at the reliability of using candlesticks to predict movement in prices by looking at the probabilities of up or downward movements of prices conditioned on the appearance of various types of candlesticks. Probabilities are calculated empirically from the co-occurrence of candlestick of each type and the up or downward movement of prices in the succeeding trading day, using data from ten markets over a 20-year period. Boxplot analysis of the data shows that candlesticks with long upper shadow and short lower shadow relative to the body length, regardless of color, generally signal an upward movement in prices. Although the probability, which ranges in the higher fifties, points to a still large possibility of error in prediction, this nevertheless indicates a possibility that combinations of candlesticks can signal trends in the market movement.

Key Words: technical analysis; price action; Japanese candlestick

1. INTRODUCTION

Market activities in a single trading day are typically summarized by the reporting of its opening, closing, highest and lowest prices. These information are visualized in chart elements called candlesticks (Mahmoodzadeh et al, 2007) which are the basic building blocks of technical analysis (Grimes et al, 2012). The information content (Fiess and MacDonald, 2006) and predictive information (Xie et al, 2012) of candlesticks have been the subject of

previous studies, but much remain to be done to ascertain the veracity and reliability of purported signals. The analytical techniques must be rooted in historical data from different markets, and it is with this in mind that we seek to lay some empirical groundwork, taking data from ten markets covering a period of 20 years. This work looks into the empirical basis of these techniques by studying the probabilities of subsequent price movements upon the occurrence of various types of candlestick.

Figure 1 depicts the different parts of a candlestick: the body, the upper shadow, and the

lower shadow. The length of the body is the difference between opening and closing prices. If closing is higher than opening, the body is light-colored. If closing is lower than opening, the body is colored dark. The length of the upper shadow is the difference between the highest price and the closing or opening price, whichever is higher. Thus, if the body is light, the upper shadow is the difference between the highest price and the closing price. If the body is dark, the upper shadow is the difference between the highest price and the opening price. The lower shadow is the difference between the lowest price and the closing or opening price, whichever is lower.

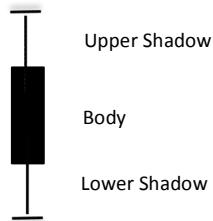


Figure 1. Parts of a candlestick

In this paper, candlesticks are classified according to the relative sizes of the shadows and the body, as shown in Figure 2. Subsequent price movement on the other hand is determined from the direction of change (upward or downward) in closing prices between two successive trading days, the first day being the day represented by the candlestick. In order to determine whether candlestick types has predictive value for subsequent price movement, conditional probabilities of market movement relative to chart type are calculated empirically for

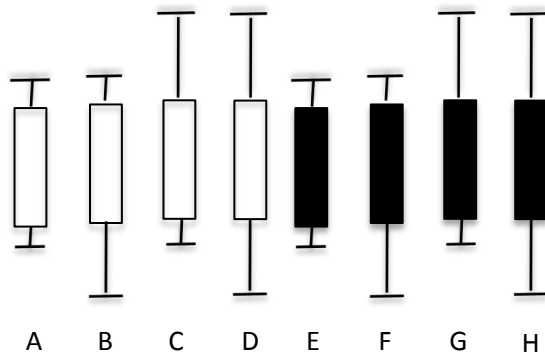


Figure 2. Classification of Candlestick Types

ten stock markets, using 20-year trading data.

2. METHODOLOGY.

Candlestick charts are classified in this study using the scheme described in Table 1 and visualized in Figure 2. The relative sizes of the shadows are determined from the ratio r of shadow length with body length. A selector value a is used to determine whether the shadow is considered short or long. If $r < a$, the shadow is considered short. If $r > a$, the shadow is taken to be long.

Table 1. Classification scheme for candlestick charts.

C Type	Body	Upper Shadow	Lower Shadow
A	Light	Short	Short
B	Light	Short	Long
C	Light	Long	Short
D	Light	Long	Long
E	Dark	Short	Short
F	Dark	Short	Long
G	Dark	Long	Short
H	Dark	Long	Long

Association between candlestick type and subsequent price movement is determined by cross tabulating candlestick type with subsequent price movement. The conditional probabilities $P(M|C)$ that a subsequent price movement type M occurs if a candlestick type C appears are calculated empirically using

$$P(M|C) = \frac{P(M \cap C)}{P(C)} = \frac{N(M \cap C)}{\sum_M N(M \cap C)}$$

where $N(M \cap C)$ is the number of times a type M movement and a type C candlestick occurred on the same day over a 20-year period from September 28, 1998 to September 26, 2018 in ten stock market indices:

- (1) Dow Jones Industrial Average (DJI)
- (2) Standard & Poor's 500 (GSPC)
- (3) NASDAQ composite (IXIC)
- (4) DAX Performance Index (GDAXI)
- (5) CAC 40 (FCHI)
- (6) Nikkei 225 (N225)
- (7) KOSPI Composite Index (KS11)
- (8) Hang Seng Index (HSI)
- (9) SSE Composite Index (SSEC)
- (10) Philippine Stock Exchange Index (PSEI)

The financial data were obtained online from finance.yahoo.com.

3. RESULTS AND DISCUSSION – COLORED CANDLESTICKS.

Candlesticks are classified in this study according to the lengths of the shadows relative to the length of the body. Since candlestick type is a nominal variable, a selector value has to be used for the classification scheme. There is however no benchmark ratio that can be set on rational grounds. The first part of this study therefore consists of finding the selector value that would yield the best possible association between candlestick type and subsequent price movement type.

The boxplot of the contingency coefficient in Figure 3 shows that a selector value of 1 yields the highest third quartile and maximum value, and appears to be the best choice for the selector. Thus, for the rest of this section, the selector value for selecting candlestick type is taken to be 1.

With selector value of 1, the conditional probabilities $P(M|C)$ for upward subsequent price movement for the eight candlestick types are shown in Tables 2 and 3. The downward conditional probabilities can be obtained from the values in Tables 2 and 3, since $P(\text{down}|C) = 1 - P(\text{up}|C)$.

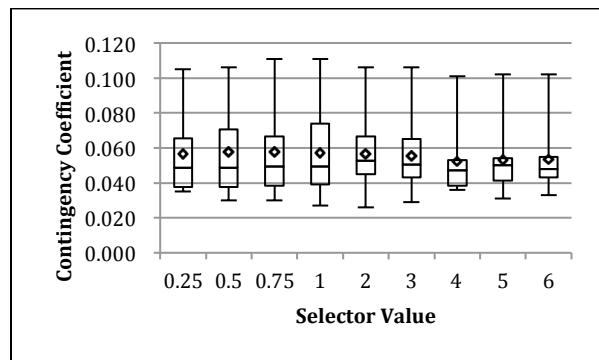


Figure 3. Boxplot of the contingency coefficients of ten stock markets for different selector values used for classifying candlestick types. The diamond markers correspond to the average value.

On the whole, for the markets considered, and for the 20-year period studied, there seems to be a general bias towards upward movement of subsequent closing prices. For candlesticks of types A and C, the subsequent closing price has higher probability of going up in 90% of the markets

considered. For types B and G, the closing price has higher likelihood of going up in 80% of the markets. The subsequent price movement has higher likelihood of going up in 70% of the markets for candlestick type D, 60% for type F, 50% for type H, and 100% for type E.

Table 2. Conditional probabilities $P(M|C)$ where M is upward subsequent price movement, and C are the light-colored candlestick types A, B, C, D, for the ten markets considered.

Market	Candlestick Type			
	A	B	C	D
DJI	0.5535	0.5482	0.6311	0.5083
GSPC	0.5718	0.5227	0.6232	0.5551
IXIC	0.5449	0.5406	0.6147	0.5640
GDAXI	0.5419	0.5282	0.5130	0.5722
FCHI	0.5292	0.5519	0.5094	0.5168
N225	0.5395	0.5015	0.5491	0.4841
KS11	0.5500	0.4799	0.5581	0.5152
HSI	0.5229	0.5219	0.5294	0.5414
SSEC	0.5418	0.5344	0.5503	0.4913
PSEI	0.4720	0.4465	0.4853	0.4608

Table 3. Conditional probabilities $P(M|C)$ where M is upward subsequent price movement, and C are the dark-colored candlestick types E, F, G, H, for the ten markets considered.

Market	Candlestick Type			
	E	F	G	H
DJI	0.5080	0.4890	0.4891	0.5365
GSPC	0.5165	0.4480	0.4795	0.5233
IXIC	0.5327	0.5335	0.5556	0.5167
GDAXI	0.5172	0.5063	0.5229	0.5424
FCHI	0.5027	0.4878	0.5488	0.4847
N225	0.5078	0.5113	0.5254	0.4736
KS11	0.5380	0.5000	0.6175	0.5299
HSI	0.5097	0.5080	0.5438	0.4945
SSEC	0.5588	0.4322	0.5694	0.4934
PSEI	0.5738	0.5714	0.5592	0.4577

An analysis of the boxplot of the probability for upward price movement shown in Figure 4 indicates that candlesticks of types F and H do not make signals at all for subsequent price movement. Although there is higher probability for upward price movement when candlesticks of types A, B, D, E appear, the signals appear to be weak as the probabilities hardly reach 0.550. Among the candlestick types, C and G seem to make clear signal for upward subsequent price movement.

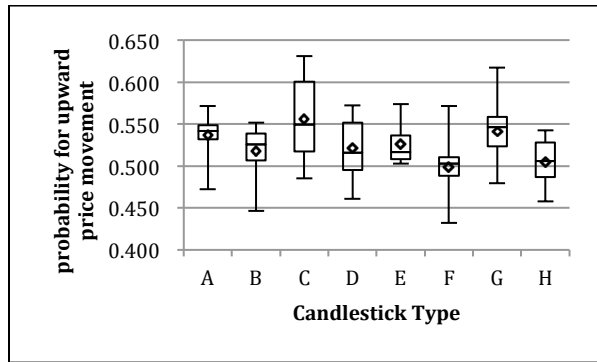


Figure 4. Boxplot of the probability for upward subsequent price movement in ten stock markets for different candlestick types. The diamond markers correspond to the average values.

4. RESULTS AND DISCUSSION – UNCOLORED CANDLESTICKS.

The boxplot in Figure 4 also shows that while the dark candlesticks have lower boxplots than the light candlesticks, one can draw the same conclusions regarding the signals made by candlestick types of different colors but the same shape. Candlesticks of type A and E both show weak signal for upward movement in prices. The signal for price movement is ambiguous for types B and F, and types D and H. Candlesticks of type C and G on the other hand show a clear signal for upward movement in prices. Analysis can be simplified if there are less candlestick categories. Since color may not be an important factor affecting candlestick signals, we consider in this section uncolored candlesticks. That is, candlesticks of the same shape regardless of color are subsumed into one category. Candlesticks of types A and E are subsumed as type J, types B and F as type K, type C and G as type L, and types D and H as type M. For uncolored candlesticks, the boxplot of the contingency coefficients shown in Figure 5 suggests that the optimal selector value is 0.75. The differences between 0.75, 1, and 0.5 however, appear

minimal.

Comparison of boxplots from Figure 6 to 8 reveals that although there are variations in the sizes of the boxplots, there is little difference in the conclusions that can be drawn using any of the three selector values. We may therefore take the selector value of 1 for simplicity, and for uniformity with our analysis in the previous section.

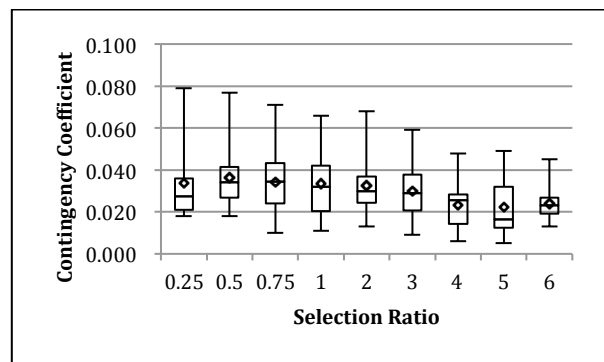


Figure 5. Boxplot of the contingency coefficients of ten stock markets for different selector values used for classifying uncolored candlestick types. The diamond markers correspond to the average value.

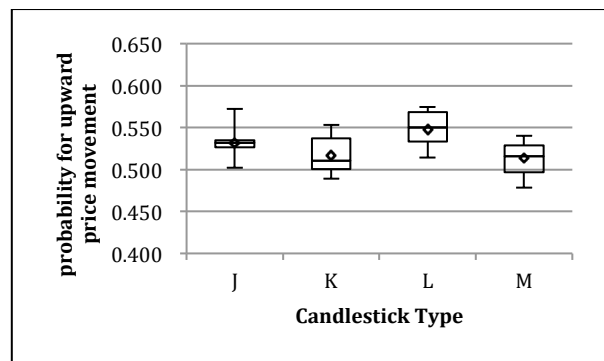


Figure 6. Boxplot of the probability for upward subsequent price movement in ten stock markets for different uncolored candlestick types when selector value is 0.5. The diamond markers correspond to the average values.

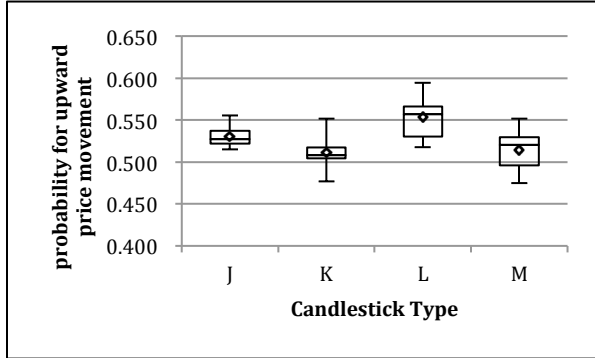


Figure 7. Boxplot of the probability for upward subsequent price movement in ten stock markets for different uncolored candlestick types when selector value is 0.75. The diamond markers correspond to the average values.

Taking a selector value of 1, it can be seen in Figure 9 that type K and M candlesticks do not show signals for upward or downward market movements. Type J candlesticks show a weak preference for upward movement with only a 54% third quartile probability. An upward disposition of the market is clearer with the appearance of type L candlesticks. But with a median probability of 54%, an average probability of 55%, third quartile probability of 56%, and maximum probability of less than 59%, this can at best be regarded as a slight tendency for upward movement.

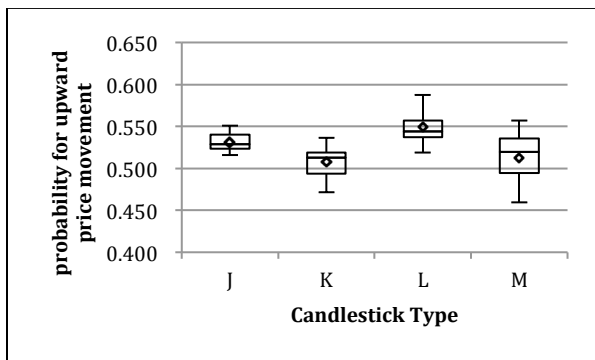


Figure 8. Boxplot of the probability for upward subsequent price movement in ten stock markets for different uncolored candlestick types when selector value is 1. The diamond markers correspond to the average values.

Table 4. Conditional probabilities $P(M|C)$ where M is upward subsequent price movement, and C are the light-colored candlestick types J, K, L, M, for the ten markets considered.

Market	Candlestick Type			
	J	K	L	M
DJI	0.5283	0.5193	0.5529	0.5221
GSPC	0.5412	0.4845	0.5455	0.5399
IXIC	0.5382	0.5368	0.5872	0.5396
GDAXI	0.5287	0.5178	0.5187	0.5571
FCHI	0.5159	0.5203	0.5306	0.5000
N225	0.5237	0.5058	0.5372	0.4790
KS11	0.5441	0.4900	0.5854	0.5224
HSI	0.5165	0.5157	0.5371	0.5168
SSEC	0.5510	0.4713	0.5586	0.4923
PSEI	0.5237	0.5101	0.5427	0.4595

5. CONCLUSION

Movements of prices in stock markets during a single trading period are typically visualized using candlestick charts. Technical analysis of the market are based on patterns found in time series of the candlesticks. In this paper, we looked at the reliability of using candlesticks to predict movement in prices by looking at the probabilities of up or downward movements of prices conditioned on the appearance of each of eight types of candlesticks, classified according to the relative sizes of the body and the shadows.

Boxplot analysis of data taken from ten markets over a 20-year period shows that the probability that the market moves up in the next trading period is highest when candlesticks with long upper shadow and short lower shadow appear, regardless of whether the market moved up or down during the first trading period. The maximum value of the probability is however lower than 64% for light candlesticks, lower than 62% for dark candlesticks, and less than 59% for uncolored candlesticks. While the signal for upward movement is clear, at best this can be regarded as a slight tendency for upward movement, as there is still a 40% chance that the market will actually fall rather than rise during the next trading period.

Candlesticks with short upper and lower shadows show an even smaller tendency for upward movement, with maximum values of probabilities



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ranging from less than 56% for uncolored candlesticks and lower than 58% for colored candlesticks.

Candlesticks of long lower shadow and short upper shadows, and candlesticks with long upper and lower shadows, on the other do not appear to signal market movement at all. In both cases, there is almost equal chances for markets to move up or down during the subsequent trading period.

Thus, while appearance of candlesticks with long upper shadow may signal upward movement in the market, this has to be taken with a lot of caution. Since trends play an important role in technical analysis, it may be unwise to rely only on single candlesticks to make predictions on market movement. Analysis involving combinations of candlestick may be needed and could be the subject of further studies.

6. REFERENCES

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