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Profitability of technical trading strategies under market manipulation



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Abstract

Most technical trading strategies use the official closing price for analysis. But what is the effect when the official closing price is subject to market manipulation? This paper answers this question by testing the difference of profitabilities between using the official closing price and the last tick price. The results show a significant improvement of profitability by using the last tick price over the official closing price based on a data set in Hong Kong from 2011 to 2018.

Introduction

The closing price is important in finance. It is the most commonly used financial data in both academia and industry. Given its importance, it is also exposed to market manipulation which is defined as stock prices being artificially influenced (Allen and Gale 1992). However, most quantitative trading strategies use the official closing price as their input. This study examines the profitability impact of closing price market manipulation on technical trading strategies.

Putniņš (2012) and Thoppan and Punniyamoorthy (2013) provide comprehensive surveys on market manipulation. Allen and Gale (1992) are early pioneers to start studies on market manipulation and formalize the study. They also introduce the concept of trade-based and information-based manipulation to classify cases of market manipulation. Aggarwal and Wu (2006) investigate cases of stock market manipulation and conclude that market manipulation alters stock returns as a result.

Market manipulation is not a problem only specific to some particular stocks. Closing prices of all stocks are also subject to manipulation especially on some particular dates. Ni et al. (2005) and Agarwalla and Pandey (2013) study the expiration-day effect; Ritter (1988) studies the end-of-year effect; Ariel (1987) studies the monthly effect; Cross (1973), Keim and Stambaugh (1984), Harris (1986), French (1980), Admati and Pfleiderer (1989), and Kamara (1997) study the weekday effect. Closing price manipulation occurs regardless of the specialty of the day.

Evidence of closing price manipulation in different financial markets has been studied in the literature. Cheung (1995) studies Hong Kong stock market; Felixson and Pelli (1999) study Finland stock market; Harris (1989), Chang et al. (1995), and Cushing and Madhavan (2000) studies the United States stock market; Hillion and Suominen (2004),

Michayluk and Sanger (2006), and Kandel et al. (2012) study the France stock market; Kucukkocaoglu (2008) studies the Istanbul stock market; McNish and Wood (1990) study the Canada stock market; Hsieh (2015) studies the Taiwan stock market; Kandel et al. (2012) study the Italy stock market; Hagströmer and Nordén (2014) study the Sweden stock market. The day-end effect on the closing price is far from an area-specific problem.

The evidence of closing price manipulation is the systematic price movement near the market close. This anomaly potentially affects everything that relies on the closing price, including return calculation and valuation. Stock exchanges over the world seek a solution to prevent closing price manipulation. Many exchanges introduce closing call auctions to determine the closing price to decrease the chance of manipulation. Comerton-Forde and Rydge (2006) investigate various algorithm designs for call auctions. They find that some algorithm designs of call auction systems can prevent manipulation. Empirically, Comerton-Forde et al. (2007), Pinfold and He (2012), Hagströmer and Nordén (2014), Huang and Chan (2014), and Kadioğlu et al. (2015) study the implementation of closing call auction in different regions. The results mainly show that closing call auction reduces manipulation. Most major exchanges adopt closing auction methodology to determine the closing price.

Additionally, Hillion and Suominen (2004) and Comerton-Forde and Putniņš (2011b) use theoretical model to study real stock manipulation cases to seek explanation for manipulation. Both models suggest strong incentives for market manipulation. With the rise of high-frequency trading possibly to exploit the opportunity, Aitken et al. (2015) find increases of manipulation in both frequency and severity. Comerton-Forde and Putniņš (2011a) and Comerton-Forde and Putniņš (2013) formulate frameworks for the measurement of manipulation in terms of frequency and severity. Bogousslavsky and Muravyev (2020) study order imbalances at the close and find that order imbalances potentially can distort closing prices.

The main goal of this study is to investigate the impact of closing price manipulation from a practical point of view. As an illustration, there is no manipulation, and the closing price is “clean” in a perfect world. In an imperfect world, there is manipulation, and the closing price is “dirty”. Between the two worlds lies the real world, where closing price methodology is designed to find the official closing price as shown in Fig. 1. Whereas the official closing price is the default choice for most financial purposes, there are flexible applications. In technical analysis, the closing price is an essential input. If the official closing price is still subject to market manipulation after the closing auction methodology, what is the impact on profitability?

Methodology

Brock et al. (1992) present a seminal empirical work on the profitability of technical analysis. The methodology adopted in this study is based on an extension of their work [see for example Chan et al. (2016)] where the objective is to show the impact on profitability in different situations.

In this study, a collection of technical trading strategies is selected from the literature. They are characterized by different parameters, but all strategies need to have the closing price as their input to compute the trading signals. Based on the trading signals, the

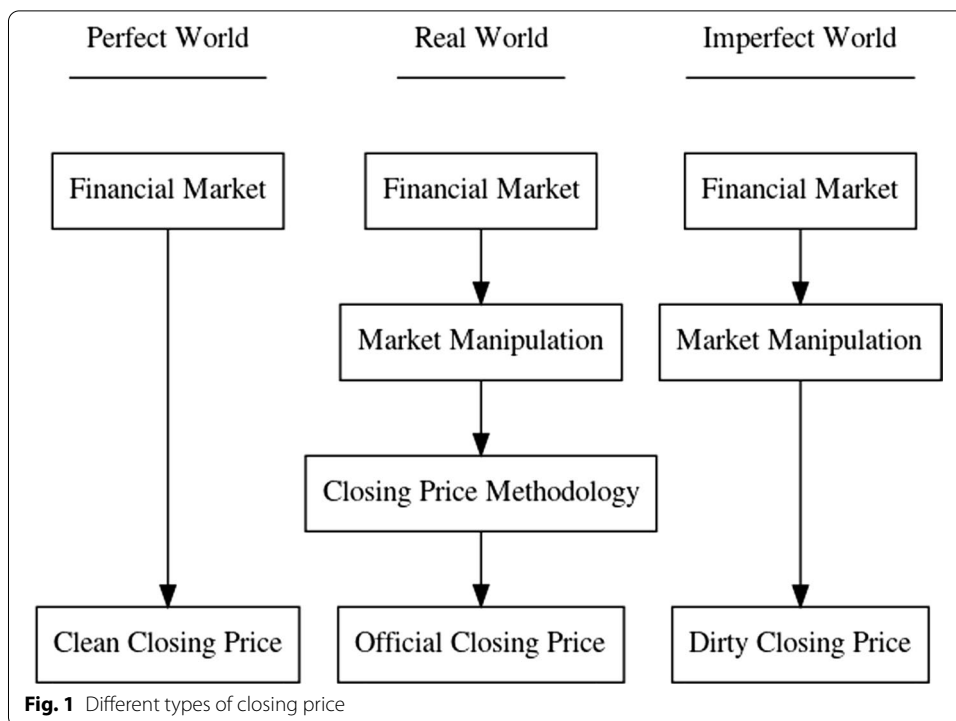


Fig. 1 Different types of closing price

profitability of each technical trading strategy can then be computed. Instead of using the closing price, the same numerical experiment is repeated with its substitute. The difference between the two computed profitabilities is then tested statistically.

For this study to make sense, the substitute of the official closing price should be chosen to reflect the stock’s true value near the market close. Otherwise, feeding random prices to quantitative trading strategies definitely can significantly change profitability, but the conclusion is meaningless. In this study, the traded price of the very last tick recorded in the continuous trading session is used to substitute the official closing price to generate trading signals. There are two reasons. First, regardless of the closing price methodology, the official closing price is still subject to manipulation and thus may not reflect the true value. Second, the last tick price is not as widely used as the official closing price. It should not be subject to the same pressure of potential manipulation. Moreover, it is the traded price nearest market close. Summarily, the last tick price is another proxy of “clean” closing price in Fig. 1.

Following Chan et al. (2016), profitabilities of various representative technical trading strategies using the official closing price versus the last tick price is compared. The strategies include Variable Length Moving Average (VMA), Fixed Length Moving Average (FMA), Trading Range Break (TRB), Relative Strength Index (RSI), and Intraday and Interday Momentum (IIM) with their full description in “Appendix”. There are 75 distinct strategies in total. The differences in profitabilities are then tested using Analysis of Variance (ANOVA) models with blocking.

Data description

The dataset covers the Hang Seng Index (HSI) constituents from 2011 to 2018 inclusively. The stock list excludes all infrequently traded stocks and captures high market capitalization. The official closing prices are collected from Bloomberg. The intraday data are collected from Hong Kong Exchanges and Clearing Limited (HKEx). There are 37 stocks with complete data, and their details are listed in Table 1.

HKEx has changed the trading hours of the stock market twice throughout the period. On March 7, 2011, they changed the lunch hour's break from 2 h to 1.5 h. On March 5, 2012, they further changed to 1 h. In addition to the lunch break, HKEx introduced

Table 1 List of Hong Kong stocks with market capitalization on December 31, 2018

Stock codes	Name	Industry	Market Cap (Billion HKD)
2	CLP HOLDINGS	Electricity Supply	224
3	HK & CHINA G	Gas Supply	249
5	HSBC HOLDING	Banks	1298
11	HANG SENG BA	Banks	336
12	HENDERSON LA	Property Development	172
16	SHK PPT	Property Investment	323
27	GALAXY ENT	Gamble	215
66	MTR CORPORAT	Public Transport	253
83	SINO LAND	Property Development	91
101	HANG LUNG PP	Property Investment	67
151	WANT CH	Diversified Food & Beverage	68
175	GEELY AUTO	Automobiles & Components	124
267	CITIC	Conglomerates	357
386	SINOPEC CORP	Petroleum & Gases	692
388	HKEX	Other Financials	283
762	CHINA UNICOM	Telecomm. Services	256
823	LINK REIT	REIT	167
836	CHINA RES PO	Electricity Supply	72
857	PETROCHINA	Petroleum & Gases	1432
883	CNOOC	Petroleum & Gases	540
939	CCB	Banks	1623
941	CHINA MOBILE	Telecomm. Services	1543
1038	CKI HOLDINGS	Conglomerates	157
1088	CHINA SHENHU	Coal	395
1093	CSPC PHARMA	Medicine	70
1177	SINO BIOPHAR	Medicine	65
1299	AIA	Insurance	785
1398	ICBC	Banks	2109
1928	SANDS CHINA	Gamble	277
2018	AAC TECH	IT Hardware	55
2313	SHENZHOU INT	Apparel	133
2318	PING AN	Insurance	1207
2319	MENGNIU DAIR	Dairy Products	96
2382	SUNNY OPTICA	Industrial Goods	76
2388	BOC HONG KONG	Banks	308
2628	CHINA LIFE	Insurance	607
3988	BANK OF CHINA	Banks	1149

Table 2 Blocking factors for ANOVA model (1)

Variable	Description
LUNCH	Three types of lunch gaps: 2 h, 1.5 h, and 1 h
CLOSING	Two types without or with Closing Auction Session
MONTH	Calendar month effects
YEAR	Calendar year effects
STRATEGY	Five classes of strategies with different parameters totaling 75 distinct strategies described in "Appendix"
STOCK	Thirty seven stocks as listed in Table 1

Table 3 Results for the ANOVA model (1)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
α_i	1	0.0	0.00247	20.140	7.20e ⁻⁰⁶
CLOSING _k	1	0.0	0.00466	38.085	6.77e ⁻¹⁰
LUNCH _j	2	0.0	0.01114	91.002	< 2e ⁻¹⁶
MONTH _l	11	0.4	0.03959	323.412	< 2e ⁻¹⁶
YEAR _m	7	0.1	0.00977	79.792	< 2e ⁻¹⁶
STRATEGY _n	74	0.0	0.00067	5.482	< 2e ⁻¹⁶
STOCK _h	36	0.5	0.01268	103.577	< 2e ⁻¹⁶
Residuals	10536595	1289.8	0.00012		

Closing Auction Session in the Hong Kong stock market on July 25, 2016. The Closing Auction Session is a trading mechanism that allows trades to be executed at the closing price. Before introducing the auction mechanism, the closing price is the 15-second average price in the last minute of the trading day. The statistical tests include these two blocking factors.

Statistical results

The following one-way ANOVA model decomposes the differences in daily returns.

$$r_{i,j,k,l,m,n,h} = \mu + \alpha_i + \text{LUNCH}_j + \text{CLOSING}_k + \text{MONTH}_l + \text{YEAR}_m + \text{STRATEGY}_n + \text{STOCK}_h + \epsilon_{i,j,k,l,m,n,h} \tag{1}$$

All blocks are specified in capital letters, and α_i denotes the variables concerned: using the official closing price or the last tick price. Table 2 describes all the other blocking factors in the ANOVA. The observed variable is the daily return of the trading strategy on a particular trading day.

The function aov in R gives the results in Table 3. Table 4 shows that using the last tick price increases profitability by 76 basis points a year (3.059300e⁻⁰⁵ × 250) compared with the use of the official closing price as inputs for technical trading strategies to compute trading signals. The difference is both statistically and economically significant. The result is also consistent across different blocking factors including the lunch hours, closing price methodologies, calendar month/year, trading strategies, and stocks. In other words, while deciding on strategies, stocks, and time to apply technical analysis makes

Table 4 Results for the ANOVA model (1)

	Coefficient estimate
Baseline	4.946672e ⁻⁰⁴
With Closing Auction Session	-6.292007e ⁻⁰⁵
Last price	3.059300e ⁻⁰⁵
Lunch gap of 1.5 h	-5.073916e ⁻⁰⁴
Lunch gap of 1 h	-5.484064e ⁻⁰⁴
February	-3.221425e ⁻⁰⁴
March	-5.466455e ⁻⁰⁵
April	7.037117e ⁻⁰⁵
May	-1.671546e ⁻⁰⁴
June	-3.076000e ⁻⁰⁴
July	-7.139136e ⁻⁰⁵
August	2.225742e ⁻⁰⁴
September	-4.773866e ⁻⁰⁵
October	-4.669616e ⁻⁰⁴
November	-4.488223e ⁻⁰⁴
December	-6.344385e ⁻⁰⁵
2012	1.231936e ⁻⁰⁴
2013	2.232818e ⁻⁰⁴
2014	6.404570e ⁻⁰⁵
2015	2.850625e ⁻⁰⁴
2016	8.499750e ⁻⁰⁵
2017	2.674325e ⁻⁰⁴
2018	1.191710e ⁻⁰⁴

Baseline refers to the estimates for $i = k = j = l = m = n = h = 1$. The coefficients for stocks and strategies are excluded

significant differences in performance, using last tick price to compute trading signals robustly improve the performance.

Discussion

The implications of the result are two-fold—both practical and theoretical. From a practical point of view, it suggests that the use of official closing price as inputs for quantitative trading strategies may not be optimal. Particularly, using the last tick price for technical analysis improves profitability. Nevertheless, the result suggests that the last tick price is the best proxy for the “clean” closing price.

From a theoretical point of view, quantitative analysis of financial data should yield useful results. Under the garbage-in-garbage-out principle, better inputs for the analysis should yield better results. When results are measured by profitability, the input showing higher profitability should be a better proxy to the “clean” closing price. In other words, this study also supports the argument that the last tick price is better than the official closing price to reflect the true market condition, possibly owing to closing price market manipulation. This result is surprising because literature generally suggests that closing price methodology such as closing call auction effectively reduces market manipulation. However, market manipulation is an adaptive process. As long as the official

closing price is still the default choice for all important financial functions such as return calculation and valuation, there will always be strong temptation and force to game the existing closing price methodology. Complete removal of market manipulation is difficult, if not impossible.

Conclusion

This study investigates the sensitivity of profitability by altering the choice of input for trading strategies based on technical analysis. Statistical results show that using the last tick price increases the profitability significantly compared to the use of the official closing price in the Hong Kong stock market. Market manipulation may affect quantitative trading strategies, and it is worthwhile to search for better inputs for quantitative trading strategies.

Directions for future studies include a similar analysis on other markets, other periods, and other stocks, including less frequently traded stocks, to draw a broader conclusion. Finally, analytical models for this area are also important to address closing price manipulation and other economic issues.

Appendix: Trading strategies

Variable length moving average (VMA)

The VMA rule generates a signal by comparing the short moving average (SMA) and long-moving average (LMA). Given a band as a requirement, if the SMA is higher (lower) than the LMA more than the band, it generates a buy (sell) signal. Following Chan et al. (2016), this study includes 1-50, 1-150, 5-150, 1-200, 2-200 (period of SMA-period of LMA) in our study.

Fixed length moving average (FMA)

The FMA strategy has a buy (sell) signal when the SMA crosses the LMA as follows: (above). Similarly, with the band as a requirement, the difference between LMA and SMA should be larger than the band to secure a signal. The holding period will be fixed as ten days according to Bessembinder and Chan (1998).

Trading range break (TRB)

The TRB strategy generates a signal if the stock price rises above the resistance (buy) or below the support level (sell). The resistance level is defined as follows: local maximum over n trading days where the support level is the minimum over n trading days. Similar to the FMA strategy, the holding period will be fixed as ten days according to Brock et al. (1992).

Relative strength index (RSI)

The RSI strategy using “50 crossover” trading rule is proposed by Wong et al. (2003). Let C_t as the daily closing price at time t . First Step, we define $U_i = \max(C_i - C_{i-1}, 0)$ and $D_i = \max(C_{i-1} - C_i, 0)$. Next, we compute $U_N(t) = \frac{1}{N} \sum_{i=t-N+1}^t U_i$ and $D_N(t) = \frac{1}{N} \sum_{i=t-N+1}^t D_i$. Finally, the RSI at time t is defined as as follows.

$$RSI_N(t) = 100 - \frac{100}{1 + \frac{U_N(t)}{D_N(t)}}$$

Accordingly, we follow the “50 crossover” method to generate the signal. When the RIS is higher than 50, it is a buy signal, and vice versa. This study includes the four rules tested, namely N equals to 5, 10, 20, 30 respectively in our study.

Intraday and interday momentum (IIM)

IIM strategies include two classes to strategies, namely intraday momentum, and interday momentum. They are based on the measurements Average Intraday Momentum (AIM) and Average Interday Momentum (AOM) are defined as follows.

$$AIM_N(t) = \frac{\sum_{i=t-N+1}^t |C_i - O_i|}{N}$$

$$AOM_N(t) = \frac{\sum_{i=t-N+1}^t |C_i - C_{i-1}|}{N}$$

This study includes 5 trading rules from Lam et al. (2007).

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Authors' contributions

The author read and approved the final manuscript.

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Declarations

Competing interests

The authors declare that they have no competing interests.

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