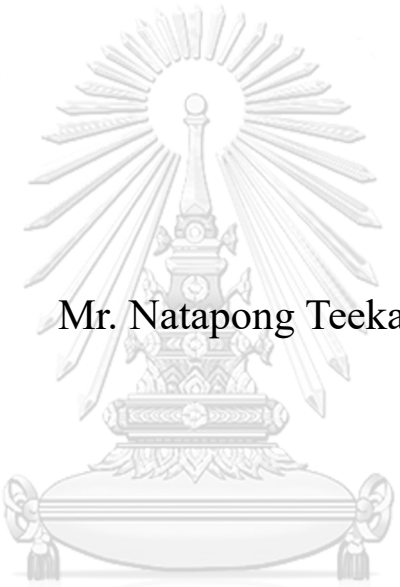
Behavioral bias in number and the stability of stock price

Mr. Natapong Teekaput



An Independent Study Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Finance
Department of Banking and Finance
FACULTY OF COMMERCE AND ACCOUNTANCY
Chulalongkorn University
Academic Year 2022

พฤติกรรมอคติทางด้านจำนวนและเสถียรภาพของราคาหุ้น

นายณัฐพงศ์ ทีฆพุฒิ

สารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาการเงิน ภาควิชาการธนาคารและการเงิน
คณะพาณิชยศาสตร์และการบัญชี จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2565

Independent Study Title	Behavioral bias in number and the stability of stock price
By	Mr. Natapong Teekaput
Field of Study	Finance
Thesis Advisor	Assistant Professor TANAKORN LIKITAPIWAT, Ph.D.

Accepted by the FACULTY OF COMMERCE AND ACCOUNTANCY, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Science

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ณัฐพงศ์ ทีฆพุฒิ : พฤติกรรมอคติทางด้านจำนวนและเสถียรภาพของราคาหุ้น. (Behavioral bias in number and the stability of stock price) อ.ที่ปรึกษาหลัก : ผศ. ดร.ธนากร ลิขิตาภิวัฒน์

This study investigates the behavioral bias in numbers. It analyzes the relationship between behavioral bias in the number of last-digit quote prices and volatility as a proxy of market inefficiency from 2 January 2020 to 30 June 2020 of penny stock in the Thailand stock market. This period is interesting because the circuit breaker triggered due to the COVID-19 pandemic. This research studies the event that exogenous effect on volatility to find that the relation between volatility and behavioral bias is still the same. The exogenous effect is the stock exchange of Thailand changed regulations by reducing the ceiling and increasing the floor to minimize the stock price volatility after the circuit breaker is triggered.

The results show that penny stock in the Thailand stock market has bias behavioral in numbers with quote prices by ending digit 0. This study does not have evidence that bias behavior in the number of quote price impact volatility. These will provide evidence to the studies from Blau & Griffith (2016).

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ปีการศึกษา 2565 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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Natapong Teekaput : Behavioral bias in number and the stability of stock price. Advisor: Asst. Prof. TANAKORN LIKITAPIWAT, Ph.D.

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Field of Study:	Finance	Student's Signature .....
Academic Year:	2022	Advisor's Signature .....

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my advisor

Asst Prof. Tanakorn Likitapiwat, Ph.D. for the continuous support of my special project, for his patience, motivation, and suggestion. His guidance helped me in all the time of research and writing of this special project.

Besides my advisor, I would like to thank the rest of my committee: Assoc. Prof. Sira Suchintabandid, Ph.D. and Professor Tanawit Sae-Sue, Ph.D., for their encouragement, insightful comments, and helpful questions.

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I. Background and Research Motivation

The Penny stock market is one of the exciting markets. U.S. Securities and Exchange Commission refers to penny stocks as small public companies that trade at less than $5 per share. In India, penny stocks refer to small public companies that sell at less than 10 rupees per share. The characteristic of penny stock is stock that has low capitalization and price. The small share price attracts market participants to invest in these stocks because some market participants expect a high benefit from an essential increase in stock price. However, these stocks have high volatility because of the small price if the change will increase vastly in proportion to the original price. The cause of the price increase is that some stocks are undervalued or that stock entered the stock market not so long ago. Then many market participants have the potential to use this cause to gain benefits from the penny stock market.

Thailand's stock market is one of the stock markets that applied the tick size rule. The tick size rule is a minimum price movement according to the price level of each stock. The minor price level in the tick size rule is less than 2 baht which tick size is 0.01 baht. SET100 is the group of stocks selected by the stock exchange of Thailand. One of the criteria used to choose is the stock has high capitalization and is in the position of the first 200 stocks. Then to select penny stocks in the stock exchange of Thailand, this research must exclude stocks from SET100.

The psychological literature found that humans have biases toward numbers because some numbers are more complex to process than others in the form of language and order. (Shepard et al., 1975) state that even-ness and odd-ness used more energy and time to process than others. (Hornik et al., 1994) used surveys with participants and found that people

bias in round numbers ending with zero and five. The other literature in finance relates to Bias in numbers. (Riccardo & Charles, 1991) and (Aitken et al., 1996) found that market participants have a fundamental attraction to specific integers are five and zero. Prior research gives fascinating discoveries and evidence about the Bias between market participants and quotes price.

To extend the research of the price behaviour much research is studied by using the name of price clustering to find the evidence of impact from this topic. Some research used price clustering in terms of the price last ending with five or zero, and some used only ending with zero or round increments. (Blau & Griffith, 2016) found that price clustering impact to volatility. In the term spread lack of information to the financial market can lead to market inefficiency.

From the prior research, this research is fascinating to find the evidence of impact from quote behaviour of market participants to volatility in penny stock at Thailand stock exchange. Because the characteristic of the Thailand stock market, which applied the tick size rule, is different from other stock markets. This research allows one to study the behaviour of market participants in this market because the evidence of this behaviour is found in many stock markets, such as Nasdaq, NYSE, India, Australia, Singapore, Taiwan, and others.

II. Objectives

The purpose of this study is as follows:

To investigate the impact of price behavior in penny stock on volatility. This study researched price behavior about the Bias in quote price by market participants. The previous research found that market participants mostly quote the price with the last digits 5 and 0. This impacts the financial market because of the lack of information on the market.

To examine the evidence of the price behavior in penny stock. This price behavior is about Bias in the last digit of the stock price of a market participant in the stock exchange of Thailand.

III. Research Contributions

This research contributes academically to finance, economics, and market participants, as described below.

First, this research contributes to the financial literature by investigating the association between return volatility and quote price. (Blau & Griffith, 2016) note that missing information to quote price in the stock market will result in more volatility in the financial market. This study will support that argument.

Second, this research helps better understand the price behavior in the Thailand stock market. The stock exchange of Thailand (SET) is one of the stock exchanges impacted by covid-19 and implemented circuit breakers.

From that result, SET has tightened regulations by decreasing the ceiling and increasing the floor to reduce the volatility of the Thailand stock market. This study uses this information to test the strong relationship

between return volatility with quote price clustering. The evidence of this helps the investor decide on the trading stock. Furthermore, this helps the firm's manager, which maximizes the shareholders' value, must be concerned with the level of volatility in penny stock from the firm's stock price because the volatility affects the firm's capital project cost.

Third, this study helps to understand investors' behavior better. (Hayek, 1945) and (Friedman, 1977) state that the financial market transmits information to the stock market in the form of price. The lack of scale from the round price reduces the information on the stock price. Investors' preference for the round price is biased or dislikes negotiation costs. It affects to get informativeness of price and leads to an increase in the volatility of the stock price.

This study contributes to the research on investment by providing evidence of a relationship between stock price volatility and price behavior in the Thailand stock market. This stock makes this research fascinating. Much previous research about this topic has a different result with a different model. Thailand has few studies on this topic. Then this research will give evidence for this topic in the research paper.

IV. Literature Reviews

To be more understanding of the relation between price behavior and price volatility. (Blau & Griffith, 2016) states that price clustering affects price volatility. That research tested exogenous effects such as Sho regulation change and the 9/11 terrorist attack, in which stock prices in the United States had much volatility. The exogenous effect does not change the relation between price clustering and price volatility.

In the study about price behavior, the research (Alexander & Peterson, 2007; Harris, 1991; Ikenberry & Weston, 2008) found that prices tend to cluster in equity and commodity markets in round increments. This unusual price behavior can be explained in two explanations. First, (Ikenberry & Weston, 2008) explain that market participants prefer round numbers to mitigate cognitive processing costs. Secondly, (Alexander & Peterson, 2007; Harris, 1991) explain that market participants prefer to minimize negotiation costs.

(Baig & Sabah, 2020) state that short selling investor impact price clustering. When a highly active short selling investor, the price clustering is lower in each level. This result from short selling investor reduces negotiation cost from reduce level of price clustering. The negotiation is costly to investor.

(Chen, 2019) states that information in the financial market is sent to the market in the form of price. Price clustering is used to hide inside information. The higher the level of price clustering, the higher efficient of hiding inside information.

(Lien et al., 2019) state that the stock exchange has clearly a price cluster at the last digits of five and zero. The smallest tick size has more obvious evidence than other tick size ranges.

To study the effect of price behavior on price volatility. (Blau & Griffith, 2016) found that the lack of information affects the relationship. They used linear Granger-like causality tests. (Granger, 1969) shows testing between two econometric variables in a time series. Variable B provides essential information to affect variable A. If we test the lag of information from B to A., we must control the lag of variable A. Then we can explain that variable B directly affects A in terms of time lag.

In addition, to test the relation between price clustering and price volatility by exogenous effect. (Baek et al., 2020) found that COVID-19 news, such as deaths and recoveries, has directly affected daily price volatility in the US stock market. (Díaz et al., 2022) found that covid-19 has an impact on price volatility. (Baek et al., 2020)and (Díaz et al., 2022), who researched the international market, found that covid-19 directly impacted price volatility. They added policy interventions to find the relation to price volatility, but the result showed that not related. They expected that the changing behavior of the population in covid-19 period is the reason for price volatility.

V. Hypothesis

Hypothesis I: Thailand's stock market has evidence of the relationship between return volatility and price behavior.

This research's primary purpose is to find evidence of the relationship between return volatility and price behavior in the Thailand stock market. The stock price behavior affects the stock price with more volatility.

Hypothesis II: The exogenous effect related to price volatility does not affect the relation between price behavior and return volatility.

Thailand's stock market has factors that affect price volatility. Therefore, to support Hypothesis I, we use SET change regulation to decrease ceiling and increase floor as an exogenous effect because we want to confirm the strong relationship between return volatility and price clustering. This effect stock market more volatility because the information of this news is transmitted to the market in the form of price.

VI. Data and Variables.

A. Data

This research obtains matched quote prices and all quote price from the Thailand stock exchange in intraday. The daily closed price opening price bid ask share outstanding and volume of each stock from Bloomberg. The penny stocks used in this research are stocks with prices under 2 baht and not in SET100 because these stocks have low market capitalization. From the tick size rule applied in the Thailand stock market, this study selected prices under 2 baht for two reasons. Firstly, the definition of penny stock is stock that trades at a low price, and then we choose the lowest range of the tick size rule. Secondly, the Range of prices under 2 baht has a tick size is 0.01 baht. This tick size does not impact this study because another price range has a tick size that some last digit numbers can't come up. For example, the price range from 2 baht to 5 baht has a tick size of 0.02 baht. Then the last digit of the stock price that is possible in this range is 2,4,6,8 and 0. This study focuses on the range that can quote in all the last digit to find the behavior bias of quote price. Then this research cannot be studied in that range.

The periods of this data stay from 2 January 2020 to 30 June 2020 because the circuit breaker triggered on 12 March 2020, and the regulator changed regulations about the ceiling and floor from 18 March – 30 June 2020. To manage the outliner, this research set data to 2 groups. First is data without inactive stock or stock that changed to less than 0.05 baht that day. The second is data with inactive stock.

To study the change regulation by SEC, this research uses data to study from 2 January to 30 June 2020. Because the regulation was temporally changed from 18 March to 30 June 2020.

B. Variables

Measure the price behavior bias in number.

The percent bias is the proportion of the matched price with the last digit (B) equal to 5 or 0 of each transaction stock i at daily test periods t. N is number of transactions in that day.

$$\%Bias_{i,t} = \frac{B_{i,t}}{N_{i,t}} * 100 \quad \text{- (1)}$$

Measure the Volatility

(Harris, 1991)and (Blau & Griffith, 2016)found that clustering increases with price level and volatility. This volatility estimated daily volume weighted volatility and calculated from the following:

$$Volatility_{i,t} = \sqrt{\frac{\sum_{m=1}^{N}(Price_{i,t,m} * Volume_{i,t,m} - \overline{VWAP_{i,t}})^2}{N_{i,t} - 1}} \quad \text{- (2)}$$

From equation (1): Price is the quoted price of the matched transaction on that day. Volume is the volume of matched transaction on that day. $\overline{VWAP}$ is the volume weighted average price (VWAP) of matched transactions on that day. N is the number of matched transactions on that day. i is selected penny stock and t is daily test periods.

Measure the illiquidity.

In this research use (Amihud, 2002) illiquidity measure (Illiq). The size and liquidity are mostly used by studies about volatility because the larger of size the lower risk, and the higher liquidity the lower risk (Cheung & Ng, 1992).

$$Illiq_{i,t} = \frac{|Return_{i,t}|}{Volume_{i,t}} \text{ - (3)}$$

From equation (2): Return is the daily return of each stock i, and Volume is daily trading volume of each stock i.

C. Data Descriptive

Table 1 summarizes descriptive statistics on variables used in regression. The mean of the volatility is 27,818, meaning the daily penny stock prices are volatile by around 27,818 on average. The meaning of Bias in behavioral numbers of quote price (%Bias) is 24.89 (or 24.89 % per day) indicating that, on average, the Bias behavioral in numbers with ending digit 0 is around 24.89% per day. The maximum change (Chg) is 56.10%, and the minimum is -31.17%. This shows that the stock price in penny stock can increase and decrease more than bigger stock due to low price.

In table 2 shows the summary of observations and stock in this research. The observation of all quote prices is 10,576,361 and matched quote price is 4,423,142. The all quote prices were used to reflect behavioral bias in number of quote price from market participants. The matched quote price was used to study the impact of behavioral bias in number impact to volatility. The value of matched quote price is less than half of all quote price because all quote price has bid quote and ask quote. The total observation of daily data and selected penny stock from 2 January 2020 to 30 June 2020 is 20,609. The quote price range is 0.1 to 1.99 baht. This research excludes observation without an opening price and percent bias of last digit of quote price with 0 with values 0% and 100%. Then the observation is 8,651. This shows that half of observations in that day that stock does not quote with last digit 0 or quote with only last digit 0. The other is some stock has 1 quote in that day. The inactive stock in this research is stock that price changed to less than 0.05 baht on that day. If we exclude the inactive stock the observation is 4,364. The number of days in this research is 123 days. The stock used in this

research with inactive stocks is 187 stocks, and without inactive stocks is 175 stocks. This interesting that half of selected observation is inactive stock with around 12 stocks. To manage the outliner, we separate to two data groups first is selected observations with inactive stock and secondly is selected observations excluded inactive stocks.

Considering the correlations among independent variables from Table 3 and Table 4, it can be implied that there is no multicollinearity problem to concern because no pair of variables correlate higher than 0.8, which is a rule of thumb for severe multicollinearity.

Table 1 presents the summary statistics of all variables from penny stock in the Thailand stock market from 2 January 2020 to 30 June 2020.

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
$Volatility_{i,t}$	8,650	27,818	73,536	28.71	4.379e+06
$\%Bias_{i,t}$	8,650	24.89	21.41	0.0600	99.08
$MktCap_{i,t}$	8,650	2,519	4,529	118.7	46,673
$Price_{i,t}$	8,650	1.075	0.515	0.0844	1.977
$TurnOver_{i,t}$	8,650	2,618	7,639	0.154	228,104
$Spread_{i,t}$	8,650	0.0204	0.0275	0	0.440
$Illq_{i,t}$	8,650	4.15e-05	0.000309	7.66e-10	0.00936
$Open_{i,t}$	8,650	3.813	3.333	0	9
$Opennear0_{i,t}$	8,650	0.693	0.461	0	1
$Chg_{i,t}$	8,650	0.185	5.112	-31.17	56.10
dailyMinQuote	8,650	1.107	0.527	0.100	1.990
dailyMaxQuote	8,650	1.044	0.504	0.0700	1.900

Table 2 presents the summary of observations and stock in this research from 2 January 2020 to 30 June 2020.

Description	Value
Total all quote price	10,576,361
Total matched quote price	4,423,142
Quote price range (baht)	0.01-1.99
Total observation	20,609
Total observation without opening price. – (1)	1,737
Total observation with %Bias is 0% or 100%. – (2)	10,221
Total observation includes inactive stocks and excludes (1) and (2).	8,650
Total observation excludes inactive stocks (1) and (2).	4,305
Total stock includes inactive stock and excludes (1) and (2).	187
Total stock excludes inactive stock (1) and (2).	175
The total day includes inactive stock and excludes (1) and (2).	123
Total day excludes inactive stock (1) and (2).	123

Table 3 presents the correlation matrix between variables from 2 January 2020 to 30 June 2020, excluding inactive stock.

	$Volatility_{i,t}$	$\%Bias_{i,t}$	$ln(MktCap)_{i,t}$	$\ln(price)_{i,t}$	$TurnOver_{i,t}$	$Spread_{i,t}$	$Illq_{i,t}$	$Open_{i,t}$	$Chg_{i,t}$
$Volatility_{i,t}$	1.0000								
$\%Bias_{i,t}$	-0.0685	1.0000							
$ln(MktCap)_{i,t}$	0.3252	-0.1271	1.0000						
$\ln(price)_{i,t}$	0.0720	0.0049	0.2993	1.0000					
$TurnOver_{i,t}$	0.3483	-0.1143	0.1276	0.0533	1.0000				
$Spread_{i,t}$	-0.1012	0.2410	-0.1744	0.0966	-0.1473	1.0000			
$Illq_{i,t}$	-0.0789	0.1803	-0.0408	0.0768	-0.0583	0.2905	1.0000		
$Open_{i,t}$	0.0250	-0.1274	0.0353	-0.0075	0.0336	-0.0653	-0.0571	1.0000	
$Chg_{i,t}$	-0.0070	0.0451	-0.0113	-0.0675	0.0233	0.1030	0.0664	0.0156	1.0000

Table 4 presents the correlation matrix between variables from 2 January 2020 to 30 June 2020 and changes the last digit of the price opening to a dummy opening price near 0.

	$Volatility_{i,t}$	$\%Bias_{i,t}$	$ln(MktCap)_{i,t}$	$\ln(price)_{i,t}$	$TurnOver_{i,t}$	$Spread_{i,t}$	$Illq_{i,t}$	$OpenNear0_{i,t}$	$Chg_{i,t}$
$Volatility_{i,t}$	1.0000								
$\%Bias_{i,t}$	-0.0357	1.0000							
$ln(MktCap)_{i,t}$	0.2125	-0.1277	1.0000						
$\ln(price)_{i,t}$	0.0529	-0.2445	0.2972	1.0000					
$TurnOver_{i,t}$	0.2044	-0.1330	0.1113	0.0957	1.0000				
$Spread_{i,t}$	-0.0422	0.0163	-0.1207	0.1789	-0.0929	1.0000			
$Illq_{i,t}$	-0.0477	0.0811	-0.0472	0.0795	-0.0455	0.2348	1.0000		
$Open_{i,t}$	0.0029	0.1948	-0.0163	-0.1727	-0.0645	-0.0618	0.0193	1.0000	
$Chg_{i,t}$	-0.0004	0.0064	-0.0150	-0.0178	0.0292	0.0984	0.0467	0.0034	1.0000

VII. Methodologies

In this research, we begin to find evidence to support the hypothesis. The first section, we find the evidence of Bias in price quote. The second section examines the relationship between price volatility and stock price clustering. Third, we examine the exogenous effect to test the strength of this relation.

A. Find the evidence of Bias in price quotes.

In this section, this research uses statistics to find evidence of Bias in quote price. This method requires the number of quote price with the same ending digit equal with other ending digit number or 10%. The other way from (Ikenberry & Weston, 2008) used the Hirshmann-Herfindal index that found evidence in the NYSE and NASDAQ stock exchanges. From the index if this market doesn't have any evidence, then the H-index is 10%. Data in this section used all quote price and matched quote price in the test periods. The test periods are from 2 January 2020 to 30 June 2020. The equation is as follows:

$$H = \sum_{i=1}^{B} (f_i)^2 \text{ - (4)}$$

The parameters meter is explained as follows:

H is Hirshmann- Herfindal index.

i is the last digit of the stock price (0,1, 2,…,9),

f_i is the frequency(percent) of each last digit of the stock price.

B. Find the relation between return volatility and price behavior.

From (Blau & Griffith, 2016) they found a relation exists between price volatility and price behavior bias in the number of matched quote price by using the linear regression equation least square with the following model:

$$Volatility_{i,t} = b_0 + b_1\%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + + b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 Open_{i,t} + b_8 Chg_{i,t} + b_9 Open_{i,t}\%Bias_{i,t} + e_{i,t} - (5)$$

Where i represents pooled selected penny stocks that price under 2 baht, exclude from SET100, and exclude inactive stock which changed less than 0.05 baht. t represents daily data from 2 January 2020 to 30 June 2020. This research uses daily data because behavior bias changes daily from the information investors get, such as the closed price from the previous day's opening price or news. The investor used the information they got to decide with his Bias to quote the price. Volatility is the daily volume weight volatility of each selected penny stock calculated from the measure of volatility. %Bias is the proportion of matched quote price ending with the last digit 5 or 0 from measurement of the Bias in behavior in number. MktCap is Market Capitalization calculated from the closing price multiplied by the number of shares outstanding. We use this parameter because (Harris, 1991) states that discrete price or price clustering less used when market value decrease. Price is average matched quote price of each stock in that day. This research used this parameter because (Harris, 1991) states that the higher the stock price, the lower the percentage of tick size valued to stock. TurnOver is Share turnover calculated from daily volume divided by the total shares

outstanding that day. The share turnover is used to measure the stock liquidity. The higher information affects stock price by trading frequency. This effect increases volatility. Spread is calculated by the difference between the daily closing bid and daily closing ask. (Chung et al., 2004) found that the higher level of clustering the higher level of spread. Illiq is an illiquidity measure from measure the illiquidity. Open is the last digit of the opening price of each stock on that day. Chg is the percentage price change between the opening price and closed price of each stock that day. This research uses Open and Chg because someday, the price will not change from lack of interest to trade from the news or the opening price is higher than investors expected. Then this led to a lack of price behavior.

$$Volatility_{i,t} = b_0 + b_1 \%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + + b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 OpenNear0_{i,t} + b_8 Chg_{i,t} + b_9 OpenNear0_{i,t} \%Bias_{i,t} + e_{i,t} \quad (6)$$

Where i represents pooled selected penny stocks that price under 2 baht and t represents daily data from 2 January 2020 to 30 June 2020. This Equation change Open to OpenNear0, which equals 1 when the last digit of the opening price equals 8,9,0,1 and 2. The others are 0. This research use OpenNear0 because Open represent that each ending digit of opening price impact to volatility but OpenNear0 represent bias with ending digit 0 or nearly ending digit 0 of opening price impact to volatility. I also add the variable interacting between OpenNear0 and $\%Bias$ to test the impact of interaction on volatility.

In this section, we focus on parameter volatility and %Bias. To support hypothesis 1, this research mainly focuses on the coefficient of price behavior bias in number 5 or 0 (b_1) to Find the evidence of the

relation between price behavior bias in number and volatility. Then b_1 must be significant to reflect that has a relation between price behavior and volatility. This section uses pooled data analysis of the individual stocks in the penny stock across the sample period.

C. regulation change from the Stock Exchange of Thailand.

To test the exogenous effect with the relation. This research selects periods when the circuit breaker has been triggered. This period has much volatility in the stock price. After applying the circuit breaker, SET (Stock Exchange of Thailand) began the temporal rule by changing the ceiling and floor to reduce the stock price volatility. In this section, we add the Reg variable to Equation 5 and Equation 6. It equals 1 during the changed regulation and 0 otherwise. Moreover, I also add the variable interacting between %Bias and Reg to capture the exogenous effect of the regulation change from the stock exchange of Thailand (Reg) affect behavioral Bias in number(%Bias). In this time frame, we use data from 2 January to 30 June 2020. Because the regulation was temporally changed on 18 March to 30 June 2020. The model we use is as follows.

$$Volatility_{i,t} = b_0 + b_1 \%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + + b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 Open_{i,t} + b_8 Chg_{i,t} + b_9 Open_{i,t} \%Bias_{i,t} + b_{10} Reg_{i,t} + b_{11} \%Bias_{i,t} Reg_{i,t} + e_{i,t} - (7)$$

Where i represents pooled selected penny stocks that price under 2 baht, exclude from SET100, and exclude inactive stock which changed less than 0.05 baht. t represents daily data from 2 January 2020 to 30 June 2020.

$$Volatility_{i,t} = b_0 + b_1\%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + +b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 OpenNear0_{i,t} + b_8 Chg_{i,t} + b_9 OpenNear0_{i,t}\%Bias_{i,t} + b_{10} Reg_{i,t} + b_{11}\%Bias_{i,t} Reg_{i,t} + e_{i,t} - (8)$$

Where i represents pooled selected penny stocks that price under 2 baht and t represents daily data from 2 January 2020 to 30 June 2020.

Equation 7 is the result of adding Reg and %BiasReg to equation 5, and equation 8 is the result of adding Reg and %BiasReg to equation 6.

To prove hypothesis 2, this section expects the coefficient of the % Bias interacts with reg (b_{10}) to be significant and same sign with b_1. If hypothesis2 is true, it means that the behavior bias in number still has an impact on volatility during the change of regulation.

VIII. Empirical results

A. Distribution of quote by ending digits.

The first methodology surveys biased behavior numbers in quote prices from 2 January 2020 to 30 June 2020. The attraction hypothesis predicts that the final digits 0 and 5 are more prevalent than the other number. When counted in this period, the ending digit of the quoted price must equal the different number to show that penny stock in the Thailand stock market does not have behavioral Bias in number. Table 5 used Thailand's stock exchange data from 2 January 2020 to 30 June 2020, where column 2 selected only matched quote prices and column 3 selected all quote prices. Table 5 and table 6's result is the percentage of the quoted price ending with each digit number in that period. Column 2 shows that the matched quoted price ending digit highest is 0 with 10.95% and 2 with 10.59%. Column 3 has the highest all quote price

ending digit 0 with 16.43%, and the second is 2 with 10.07%. The result from the last digit of the quoted price in Table 5 is not so clear except ending with digit 0 in all quote price. These findings partially support that penny stock of the Thailand stock market has behavioral bias in number of quote price. According to the methodology hypothesis1, every final digit number must equal each other. Still, from the result, this can imply that penny stock in the Thailand stock market has biased behavioral numbers in all quote price, but matched quote price does not have clearly evidence of biased behavioral numbers.

The Hirshmann - Herfindal index (H index) in Table 5, shows that the matched quote price has H-index in column2 is 10.03%, and all quote price in column 3 is 10.48%. This result is not higher than 10% significantly. From (Ikenberry & Weston, 2008) state that H-index is 10% indicate that does not have bias in quote price. This means penny stock does not have a behavioral bias in quote price.

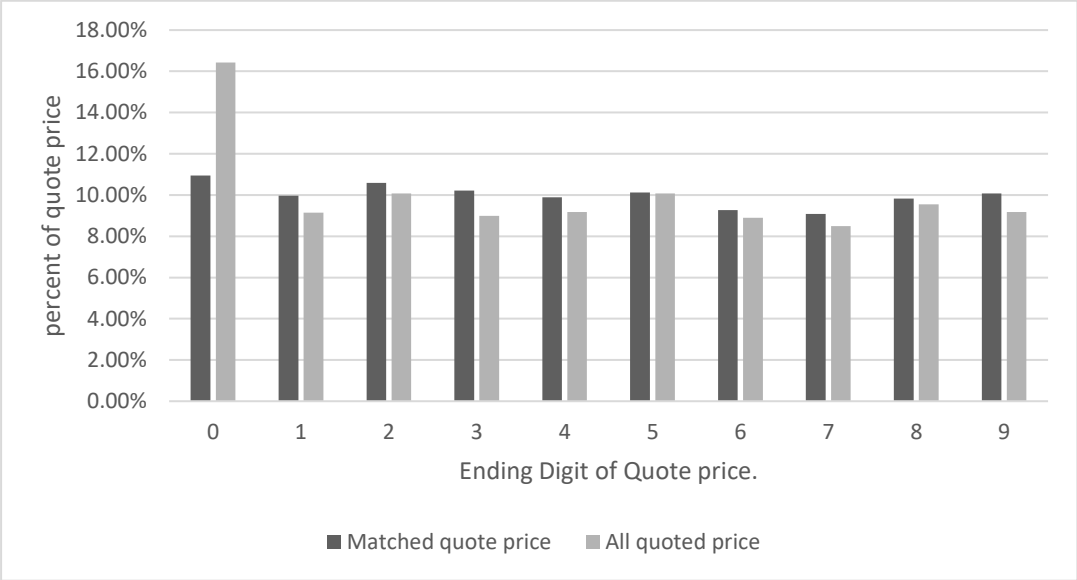
In summary, from the distribution of the final digits of the quoted price. We found behavioral bias in quote price in all quote prices from uniform but matched quote prices, and H-index does not have evidence of behavioral bias in quote prices. The interesting of this result, we will use the ending digit is 0 to study further the relation between behavioral bias in number and volatility. The other considered this research selection used matched quotes in that period to study the next section because the matched price is described as information that spread to the financial market in the form of price (Blau & Griffith, 2016).

Table 5 Quote price ending digit in January – June 2020 periods.

Ending digit	Matched quote price	All quoted price
0	10.95%	16.43%
1	9.97%	9.15%
2	10.59%	10.08%
3	10.21%	8.99%
4	9.89%	9.18%
5	10.13%	10.07%
6	9.27%	8.90%
7	9.08%	8.50%
8	9.83%	9.55%
9	10.08%	9.17%
Total	100%	100%
SD	0.55%	2.31%
Even-ness	50.53%	54.14%
Odd-ness	49.47%	45.86%
H-index	10.03%	10.48%

We are using the January – June 2020 intraday quote price from the stock exchange of Thailand. We calculate the daily number of matched quotes price in this period shown in column 2 and calculate the daily number of all quotes price in this period shown in column 3.

Figure 1 Ending digit of quote price in January – June 2020 periods.



B. The price behavior bias in quote price affects volatility.

From the previous section, this research found that quote prices in the stock exchange of Thailand mostly end with 0 digits. This section uses this result to investigate the impact of behavioral Bias in numbers on volatility. The second methodology predicts that the volatility is associated with behavioral Bias in numbers. Table 6 provides the regression result of the model (5) and model (6). Then we will interpret Model 5. The coefficient of percent bias (b_1) is not statistically significant. It indicates that biased price does not impact intraday volume weight volatility, inconsistent with the evidence (Blau & Griffith, 2016). The plausible explanation is that the market participant quoted price with a digit ending 0 does not impact the volatility of that stock, this does not lead to market inefficiency.

Considering the coefficient of the control variable, the logged market capitalization (b_2) is market value. It has a significant positive relationship with volatility at a 1% significant level, this positive does not support the higher volatility when market value decreases (Harris, 1991). The coefficient of the logged average of quote price on that day (b_3) is negative and statistically significant at a 5% level. This result does not support that the higher the stock price, the lower the percentage of tick size valued to stock. The market participant will lack awareness when quoting prices. Then this causes more volatility in the stock (Harris, 1991). The coefficient TurnOver (b_4) is positive and statistically significant at the 1% level. This result supports that higher information affects stock prices by trading frequency, leading to increased volatility (Blau & Griffith, 2016). Spread (b_5) is not statistically significant. This result does not support that the higher the price level, the higher the

spread and causes higher stock price volatility (Chung et al., 2004). The coefficient of (Amihud, 2002) liquidity ratio (b_6) has a significantly negative relationship with volatility at a 1% significant level. This evidence supports that the larger the size, the lower the risk and the higher the liquidity. It leads to lower volatility (Cheung & Ng, 1992). The coefficient of the last digit of price opening (b_7) is a strong negative relationship with not significant. This implied that the ending of the price opening did not impact volatility. The coefficient of change of the stock price of that day (b_8) is not statistically significant. The result implies that the change in the stock price of that day does not impact the volatility of the stock price. The coefficient of the last digit of opening price and percent bias on volatility (b_9) is not statistically significantly. The result implies that the percent bias with last digit of the opening price does not impact the volatility of the stock price.

In model (6), The interesting is the coefficient of the logged average of quote price on that day (b_3) is not statistically significant. This result shows that average price on that day does not impact volatility when including inactive stock prices. The coefficient of OpenNear0 (b_7) is not statistically significant. This implied that the ending digit 8,9,0,1, and 2 of the price opening does not impact volatility. Then the coefficient of the last digit of the opening price near 0 and percent bias on volatility (b_9) is not statistically significant. The result implies that the percent bias with the last digit of the opening price near 0 does not impact the volatility of the stock price.

From this result, we can conclude that behavior bias number of quote prices with ending digit 0 does not impact volume weighted volatility.

Table 6 Regression results of %Bias on volatility.

This table shows the results of the regression model (5) and model (6) that test the relationship between %Bias on volatility and other control variables to provide support for H1. The definition of variables is provided in Appendix A.

$$Volatility_{i,t} = b_0 + b_1 \%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + + b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 Open_{i,t} + b_8 Chg_{i,t} + b_9 Open_{i,t} \%Bias_{i,t} + e_{i,t} \quad (5)$$

$$Volatility_{i,t} = b_0 + b_1 \%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + + b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 OpenNear0_{i,t} + b_8 Chg_{i,t} + b_9 OpenNear0_{i,t} \%Bias_{i,t} + e_{i,t} \quad (6)$$

VARIABLES	Model_5	Model_6
%Bias	106.9	18.45
	(75.88)	(85.19)
ln(MktCap)	14,473***	13,905***
	(719.2)	(774.6)
ln(Price)	-3,911**	-2,170
	(1,818)	(1,361)
TurnOver	1.504***	1.789***
	(0.0668)	(0.101)
Spread	16,932	28,988
	(20,856)	(29,574)
Illq	-8.869e+06***	-7.581e+06***
	(2.440e+06)	(2.547e+06)
Open	366.6	-
	(353.7)	
Chg	-93.61	-41.32
	(104.1)	(149.5)
Open * %Bias	-17.93	-
	(15.79)	
OpenNear0	-	1,941
		(2,539)
OpenNear0 * %Bias	-	17.10
		(93.77)
Constant	-83,812***	-78,488***
	(5,520)	(6,096)
Observations	4,305	8,650
R-squared	0.205	0.080

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 F-statistics of the impact of behavioral Bias in the number of quote prices and last digit opening price on volatility when excluding inactive stock.

Variables	Volatility
%Bias + Open * %Bias	88.97
F-test	1.87
P-value	0.1712

Table 8 F-statistics of the impact of behavioral Bias in the number of quote prices and last digit opening price near 0 on volatility.

Variables	Volatility
%Bias + OpenNear0 * %Bias	35.55
F-test	0.74
P-value	0.3890

C. The price behavior bias in quote price effect the change of Regulation.

This section adds variable Reg and the variable interacting between %Bias and Reg to capture the exogenous effect from regulation change from the stock exchange of Thailand (Reg) affect relation between behavioral Bias in number (%Bias) and volatility to equation 5 and equation 6. The equation after adding these variables to equation 5 is equation 7. Equation 8 is equation after adding these variables to equation 6. Equation 7's data excludes inactive stock. Reg is a Dummy variable set to 1 when the selected stock falls into changed regulation periods which changed to reduce the volatility of the stock price. The changed regulation periods are 18 March – 30 June 2020. Other period Reg is 0. The coefficient of regulation changed period (b_{10}) in column 2 does not statical significant but in column 3 is statical significant at 10% level implying that changes in regulation help reduce volatility when including inactive stock. The result from table 10 shows that the coefficient of the impact of behavioral Bias in the number of quote prices on volatility when regulation changed is positive at a 10% significant level but the result from table 11 shows that the coefficient of the impact of behavioral Bias in the number of quote prices on volatility when regulation changed is not significant. This implies that when changed regulation, does not have evidence of behavioral bias in number of quote price impact to volatility except active stock that has the evidence. This result does not have evidence to support hypothesis 2 that the exogenous effect related to price volatility does not affect the relation between price behavior and return volatility. This result provides evidence to the studies from (Blau & Griffith, 2016) and (Harris, 1991).

Table 9 Regression results of %Bias on volatility when SET change regulations.

This table shows the results of the regression model (7) and model (8) that test the relationship between %Bias on volatility and other control variables to provide support for H2. The definition of variables is provided in Appendix A.

$$Volatility_{i,t} = b_0 + b_1\%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + +b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 Open_{i,t} + b_8 Chg_{i,t} + b_9 Open_{i,t}\%Bias_{i,t} + b_{10} Reg_{i,t} + b_{11}\%Bias_{i,t} Reg_{i,t} + e_{i,t} - (7)$$

$$Volatility_{i,t} = b_0 + b_1\%Bias_{i,t} + b_2 ln(MktCap)_{i,t} + +b_3 \ln(price)_{i,t} + b_4 TurnOver_{i,t} + b_5 Spread_{i,t} + b_6 Illq_{i,t} + b_7 OpenNear0_{i,t} + b_8 Chg_{i,t} + b_9 OpenNear0_{i,t}\%Bias_{i,t} + b_{10} Reg_{i,t} + b_{11}\%Bias_{i,t} Reg_{i,t} + e_{i,t} - (8)$$

VARIABLES	Model_7	Model_8
%Bias	36.85	21.50
	(93.11)	(95.58)
ln(MktCap)	14,430***	13,801***
	(721.4)	(775.2)
ln(Price)	-3,736**	-2,114
	(1,830)	(1,363)
TurnOver	1.509***	1.821***
	(0.0674)	(0.102)
Spread	16,444	24,104
	(20,959)	(29,625)
Illq	-8.936e+06***	-7.643e+06***
	(2.443e+06)	(2.547e+06)
Open	384.8	
	(354.0)	
Chg	-87.23	-25.53
	(104.3)	(149.5)
Open * %Bias	-19.36	
	(15.84)	
Reg	-2,731	-4,173*
	(2,225)	(2,410)
%Bias * Reg	126.8	-10.60
	(98.98)	(72.25)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 10 Regression results of %Bias on volatility when SET change regulations (Continue).

VARIABLES	(1) Model_7	(2) Model_8
OpenNear0	-	1,919
		(2,538)
OpenNear0 * %Bias	-	17.13
		(93.77)
Constant	-81,929***	-75,155***
	(5,768)	(6,311)
Observations	4,305	8,650
R-squared	0.206	0.081

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 11 F-statistics of the impact of behavioral Bias in the number of quote prices on volatility when regulation changed when excluding inactive stock.

Variables	Volatility
%Bias + %Bias * Reg	163.65
F-test	3.43
P-value	0.0640

Table 12 F-statistics of the impact of behavioral Bias in the number of quote prices on volatility when regulation changed.

Variables	Volatility
%Bias + %Bias * Reg	10.9
F-test	0.01
P-value	0.9035

IX. Conclusion

The purpose of this paper is to examine the relationship between behavior bias in the number of quote price and volatility, which reflect market stock inefficiency. The data were collected from the Stock Exchange of Thailand (SET) during January – March 2020. This research views volatility as market inefficiency and the last digit of the quoted price as price behavior because the human is biased with a number. My findings confirm that price behavior in quote price does not impact volume weight volatility.

Moreover, this study found that in Thailand's stock market, the behavioral Bias in numbers is 0 more than other numbers significantly, but 5 is not outstanding other numbers as described (Blau & Griffith, 2016) and (Harris, 1991). This implied that behavior bias in penny stocks in the Thailand stock market is different from other stock markets. From this evidence, market participants can benefit from this research by being careful of quote price because matched quote price does not have evidence of behavioral bias.

My finding provides an understanding of quote price behavior that impacts volatility, which benefits many groups in the financial market, such as investors and market participants. In addition, it can help researchers understand market participants' behavior when quoting stock market prices. Besides, this research focuses on the data in Thailand, which applies the tick size rule, ceiling, floor, and circuit breaker so that the result may apply to other countries' research whose market has the same characteristic.

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