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Stock Market Reaction to Political Regime Change in Malaysia

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Abstract: Research Question: How does a change in the ruling party impact the value of actively traded stocks in Malaysia? **Motivation:** The 2018 general election results is a never seen before phenomenon that can be classified as a political risk that affects the value of actively traded stocks in the Malaysian stock market. **Idea:** This study aims to investigate the impact of a change in government on share price and length of time needed for market adjustment. **Data:** The sample is based on 656 listed stocks on 9th May 2018 which was the election date in Malaysia. Data is obtained from Thomson Reuters Datastream. **Method/Tools:** Event methodology is used to identify abnormal returns (AR) and cumulative average abnormal returns (CAAR) as a measure on the impact of the election on stock prices. AR is averaged across firms to minimize other event effects, thus providing a better measure of the effect of the announcement event. The CAAR represent the average total effect of the event across all firms. **Findings:** This paper provide evidence that a significant political announcement such as election results which is followed by a government change would affect the value of actively traded stocks. The impact is found to be significantly positive CAAR on the selected event windows for both pre and post-event day. This study also finds 67 active trading days is insufficient for the market to recover from a political regime change as the stock market appears to be experiencing volatility during the observation period. **Contributions:** This study is different from other studies in two ways: (1) To our knowledge, there is no study that has yet to investigate the impact of a change in the ruling government on the Malaysian stock market; and (2) This study uses event methodology which would neatly capture specific political events such as dissolution of parliament, election results and delivery of 10 key promises by the newly elected ruling coalition and provide insight of not only the impact a change in ruling party but also immediate reforms made by the new government on the stock market.

Keywords: Bursa Malaysia, efficient market hypothesis, event study, political risk, Malaysia 2018 general election.
JEL Classification: D82, G14, G40

1. Introduction

Since independence in 1957, Malaysia has been governed by the same ruling coalition, Barisan Nasional. The coalition consists of various political parties from Peninsular Malaysia and the Borneo states of Sabah and Sarawak. On May 9th, 2018 after a 61-year rule, Malaysia witnessed its first federal government change when the opposition coalition party, Pakatan

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Harapan won 121 seats out of 222, effectively earning majority seats and appointed as the ruling coalition for the next five years. Tun Dr. Mahathir Mohamad (previously Malaysia's 4th Prime Minister) was reappointed as the 7th Prime Minister and a new set of ministers were appointed to fulfil the various roles that have been vacated by the old regime. A new government means that a new set of ministers would be appointed, resulting in a change in policies and future direction of the country.

Because the impact and repercussions of a political regime change on the Malaysian stock market has never been documented before, it is important that this change be quantified to determine the impact of political risk on share price. Event study methodology is a common tool used by researchers to investigate the impact of an event on firm value. Introduced by Fama *et al.* (1969), the authors claimed that changes in stock price are due to uncertainties in the market and concerns on whether the firm is able to maintain earnings despite uncertainties. Investors will use whatever information available to reduce uncertainty, therefore political announcements regarding a political regime change would very likely have an impact on future earnings of the firm.

Unlike event studies that focuses on firm announcements, dividend pay-outs, stock splits and other firm related information, the impact of a political event on firm value is manifested differently. This is because, firm related information is usually absorbed quickly into the firm's share price. A change in government, on the other hand, results in a change in policies and this may create uncertainties as to would the firm still be able to maintain its earnings when the policymakers or ruling government change. This paper aims to reveal not only the impact of the recent Malaysian political announcement on share price but also the length of time that is needed for the market to adjust to the change in a new government i.e. political ruling party.

Due to the lack of change in the Malaysian political regime, there have been very few studies focusing on political risk in Malaysia. Among the few is Liew and Rowland (2016) who studied the impact of five most recent political elections in Malaysia from 1995 until 2013. They found that the stock market was unaffected by the elections in the first three elections, i.e. in 1995, 1999 and 2004. However, as the opposition party formed alliances among themselves and attained a larger following, political uncertainty became significant in the 2008 and 2013 elections.

According to the authors, the FTSE Bursa Malaysia Kuala Lumpur Composite Index (FBMKLCI) had fallen by 22.88 points two days before the 2013 election, indicating the presence of political uncertainty as investors fear that the ruling party may lose to the opposition. One day after the election results were announced, FBMKLCI hit the highest historical peak and gained 96.29 points. The authors concluded that this indicated resumed confidence by the investors as it has been determined that the same government will be ruling the country for another five years.

The FBMKLCI consists of 30 of the largest companies listed on Bursa Malaysia and is frequently used as an indicator of the Malaysian stock market. Figure 1 depicts the movement of FBMKLCI from April 2018 until July 2019. Since the change in the government administration, the movement of FBMKLCI has been capricious, reflecting the uncertainties in the market following the new government administration. Kumar (2018, July 7) state that FBMKLCI has been persistently negative in the two months following the election, with the stock market experiencing a net foreign outflow of MYR10.77 billion between May to June 2018. It can be seen in Figure 1, for a one-year period between the period of May 2018 until May 2019 FBMKLCI appears to be on a downward trend.

Source: Yahoo Finance (2019)

Figure 1: FTSE Bursa Malaysia KLCI, April 2018 until July 2019

Based on the movement of the index, it appears that negative information is perceived by investors and absorbed by the FBMKLCI for the first year of the Pakatan Harapan government's rule. However, since FBMKLCI only consists of 30 stocks, this scenario may be different for other firms. Hence, this study utilises all firms that are actively traded in the Malaysian stock market. This would allow us to see the overall impact of the political announcement towards shareholders' wealth for all publicly-listed firms in the Malaysian stock market.

Figure 1 also reveal a trickle-down effect on the FBMKLCI as the new government assume control and issue directives such as the introduction of several new policies that would directly affect firm earnings and performance in selected industries. Among them are the abolishment of Goods and Service Tax (GST) to reimplementation of Sales and Service Tax (SST), introduction of a managed float system for the calculation of gasoline and diesel prices, targeted fuel subsidy program to the lower income group, and a review of all the mega projects awarded to foreign countries (Pennington, 2018, December 11; The Star, 2018, August 17; Yong and Ng, 2019, October 7). These changes are among the 10 key promises that the new government had promised to fulfil within the 100 days of being in power.

This study is different from other studies in two ways. Firstly, to our knowledge, there is no study that has yet to look into the impact of government change on the Malaysian stock market. Secondly, unlike an earlier study on the Malaysian general election by Liew and Rowland (2016) that utilizes ordinary least squares (OLS) regression in their study, this study uses abnormal returns (AR) and cumulative abnormal returns (CAAR) to measure the impact of the political event on stock prices. This would allow us to neatly capture specific political events such as the dissolution of parliament, election day and the delivery of 10 key promises[1] by the newly elected ruling coalition. Therefore, this paper will be able to provide insight of not only the impact a change in ruling party but also the impact of immediate changes

[1] Based on The Star Report card: Pakatan's 10 promises in first 100 days (The Star, 2018, August 17).

implemented by the new Pakatan Harapan government as promised in their 100-day manifesto[2] on the financial market.

2. Literature Review

Efficient market hypothesis postulates that asset prices fully reflect all available information (Fama *et al.*, 1969) and prices will change in response to new information. New information can be due to internal changes such as new appointment, termination or retirement of the management team, or announcements that bear financial impact to the firm such as earnings announcements, capital restructuring etc. New information can also be due to market information or other external news such as changes in government policy, new tax policy, the election of a new president, changes in trade agreements and many more that can result in economic uncertainties. Desai (2011) in his interview with Eugene Fama quotes the economist as saying, "*as economic uncertainties increase, volatility in asset prices will also increase*". Hence a regime change would create economic uncertainties and cause asset prices to change as new information is absorbed by the market.

There already exist a significant number of literatures on the impact of regime change on asset prices in other countries. A study by Pantzalis *et al.* (2000) on the movement of stock market indices around political election dates across 33 countries between the period of 1974 until 1995 found strong abnormal returns leading up to election day in two circumstances; (1) in less free countries won by the opposition, and (2) when the election was called early and the incumbent government lost in the election. This is supported by Ahmed (2017) who conducted a study on the impact of political regime change on the Egypt stock market between the period of 2011 and 2014 and found that although there was a volatility effect in the stock market during the two presidential elections in 2012 and 2014, most sector indices responded positively to both elections. Similarly Smales (2014) in his study on political uncertainty surrounding elections in Australia and its impact on the stock market find that higher levels of uncertainty around the election would result in higher levels of market uncertainty and vice versa.

This is in line with the uncertain information hypothesis proposed by Brown *et al.* (1988, 1993) which states that when analysed separately, immediate price changes induced by either favourable or unfavourable events will be followed by positive returns during the post-event period. This hypothesis also states that the market reacts randomly to information and asset prices may not reflect all available information instantaneously. This is as evidenced in Figure 1 where the FBMKLCI appears to be erratic for the one-year period post GE14 as market participants react to announcements and deliberations made by the new government.

After GE14, there are several factors and events that may have caused the stock market to perform erratically. Firstly, the new government had created and distributed thousands of copies of their election manifesto, Buku Harapan which contained promises on changes that will be implemented should they win the election. After winning the election, 10 key promises were identified and promised by the government to be implemented with the first 100 days of being in office. The 10 key promises and its announcement dates are tabulated in Table 1.

The policy changes as presented in Table 1, implemented by the new government affect companies in different sectors. The impact is experienced by the affected firms at different times i.e. when the decisions are announced to the public. The repercussions of these announcements may have a positive or negative impact towards the particular firms' share price in line with investors' concerns as to how the firm's performance will be affected by this announcement.

[2] 100 days manifesto refers to the Pakatan Harapan's promises to the people of Malaysia on the steps they will take when they become the government. It includes the policies and actions promised by the coalition (Pakatan Harapan, 2018).

Table 1: 10 key promises in the first 100 days manifesto by Pakatan Harapan

No.	Key Promises	Announcement date
1	Abolish the GST and take steps to reduce the cost of living	1st June 2018
2	Stabilise the price of petrol and introduce targeted petrol subsidies	18 May 2018
3	Abolish unnecessary debts that have been imposed on FELDA settlers	8 August 2018
4	Introduce EPF contribution for housewives	15 August 2018
5	Equalise the minimum wage nationally and start the processes to increase minimum wage	14 August 2018
6	Postpone the repayment of PTPTN for all graduates whose salaries are below RM4,000 per month and abolish the blacklisting policy	26 June 2018
7	Set up Royal Commissions of Inquiry on 1MDB, FELDA, MARA and Tabung Haji, and to reform the governance of these bodies	4 July 2018
8	Set up a Special Cabinet Committee to properly enforce the Malaysia Agreement 1963	21 July 2018
9	Introduce Skim Peduli Sihat with RM500 worth of funding for the B40 group for basic treatments in registered private clinics	No date available since it is unsuccessfully implemented during the 100 days period.
10	Initiate a comprehensive review of all mega projects that have been awarded to foreign countries	30 May 2018

Notes: Information above is extracted from The Star (2018, August 17).

In his study, Lee (2020) finds that the impact of economic reforms such as the implementation of 10 key promises introduced by the new ruling party affect economic growth and weakened the fiscal capacity of the government. Among them are: (1) the change from GST to SST resulted in a revenue gap amounting to RM22 billion in 2019; (2) an expenditure of RM150 million was required to stabilize and control the price of seven essential goods and services and review of companies such as Padiberas Nasional Bhd., Puspakom, Pharmaniaga Bhd. and MyEG Services Bhd. was made on their monopoly over the supply of certain goods and services; (3) introduction of targeted petrol subsidies to the lower income group; (4) an offer to acquire four tolls in 2019 amounting to a total cost of RM6.2 billion; (5) review and downsizing of mega projects such as the East Coast Rail Link (ECRL), the Kuala Lumpur – Singapore High Speed Rail (HSR), Mass Rapid Transit 2 (MRT2) and the Trans-Sabah Gas Pipeline and many others.

After GE14, FBMKLCI drastically lost value after the historical win by Pakatan Harapan, where the information of a government changes and along with it the uncertainty of introduction of new policies and cancellation of old policies is absorbed by the index. Pastor and Veronesi (2010) concurs, stock prices should respond at each step of the way with bigger price responses following bigger increases in the probability of a policy change. In their study, they found that on average, stock prices fall at the announcements of policy changes – the price fall is expected to be large if uncertainty about government policy is large. The authors conclude that policy changes increase volatility, risk premia and correlations among stocks.

According to Franck (2020, Feb 27), historical analysis shows that market corrections that result in a 13 per cent decline can take about four months to recover to prior levels, on average. CNBC and Goldman Sachs analysed 26 market corrections in the United States since World War II and found that market corrections with an average decline of 13.7 per cent recovers within a period of four months. While bear markets with an average decline of more than 30 per cent takes about 24 months to recover. In the case of Malaysia, it is uncertain how long will the market recover after a political regime change, hence for this study, a 100-day benchmark is used in line with the 100-day manifesto presented by Pakatan Harapan.

Event study methodology is commonly used to measure security price reaction to some announcement or event (Binder, 1998) and the length of time needed by the firm(s) to recover from the event. Introduced by Fama *et al.* (1969) the practice of calculating abnormal returns (AR), average abnormal returns (AAR) and cumulative average abnormal returns (CAAR) have become a familiar method in event study research. This method has been established as one of the techniques that can be used to produce valid results about the average effect of an event on sample firms (Binder, 1998). Based on the focus of interest in this study and the above literature discussion, the hypothesis for this study are as follows:

H_0 Regime change are associated with insignificant abnormal market returns over the selected event windows.

H_a Regime change are associated with significant abnormal market returns over the selected event windows.

3. Methodology

3.1 Sample Selection and Data Collection

As mentioned above, this study aims to determine the impact of the political regime change in Malaysia stock market with reference to the 14th General Election 2018 (GE14). The date 9th May 2018 was the election day in Malaysia and is selected as event day (t_0) in this study. But due to the public holiday on that day and the new government declared another two days of public holiday, the announcement date (t_0) selected for this study is the next trading day, which is 14th May 2018. This study is interested to see how the investors react to the news i.e. Election Commission announcement of the polling date, official campaigning period, the poll results and also the 10 key promises in the first 100 days manifesto by the new government that would give impact to stock prices in Malaysia.

The investigation period is from 28th March until 17th August 2018, yielding 97 daily observations. The data will be divided into two sub-periods. The first sub-period examined from 28th March to 14th May 2018 and called as pre-event window (28 days observation period). Four selected event windows are chosen to capture the important date before polling date i.e dissolution of Parliament (t_{-29} days), nomination process and official 11-day campaigning period (t_{-6} days) and early voting begins (t_{-2} days)[3]. This is important to see the socio-political conditions before the election (Welsh, 2018). While the second sub-period examined is from 14th May 2018 to 17th August 2018 (marking 100 days as a new Malaysia) and called as post-event window. Eight[4] selected events windows are chosen based on the announcement of the successful or unsuccessful delivery of 10 key promises in Pakatan Harapan's election manifesto in first 100 days. The idea is to see the impact of the new government key promises on the financial market.

For the sample selection, initially it was 812 listed companies in Bursa Malaysia. Due to unavailability of data, the final sample was 656 listed companies only. Daily stock closing prices and the market index, namely the Kuala Lumpur Composite Index (FBMKLCI Index), were obtained from *Thomson Reuters Datastream.*

3.2 Event Study Methodology

The method that is most suitable so far in measuring the reaction of security prices to the election day of Malaysia is event study methodology. An event study is able to measure the magnitude of the abnormal share price performance at the time an event is announced, i.e. the election which resulted in a change of government and provide a measure of the (unanticipated) impact of this event on security prices.

[3] If the date is fall on the weekend or public holiday, the next trading day will consider as event window.

[4] One of the promises is unable to fulfil during the first 100 days and another two promises shared the same date.

The study applies the market model, Fama *et. al* (1969) a one factor ordinary least squares (OLS) regression equation to estimate the expected returns. This is the approach to estimate the relationship between a share's returns and returns on the market (FBMKLCI). So,

$$E(R_{jt}) = \alpha_{jt} + \beta_{jt} R_{mt} + \varepsilon_{jt} \quad (1)$$

where α_j and β_{jt} are regression coefficients and ε_{jt} is the error term. Having calculated estimates of α_j and β_{jt} with data from an estimation period, the expected return is given by inserting the estimated values of α_j and β_{jt} together with the actual return on the market (Armitage, 1995). The effect on the rate of returns on security *j* is as follows:

$$AR_{jt} = R_{jt} - E(R_{jt}) \quad (2)$$

Then the average abnormal returns *(AAR)* for a sample of N securities for each day are calculated as:

$$AAR_t = \frac{1}{N} \sum_{j=1}^{N} AR_{j,t} \quad (3)$$

where *N* is the number of firms with abnormal returns on day *t.*

The AR is averaged across firms to minimize other event effects, thus providing a better measure of the effect of the announcement event. The cumulative average abnormal return (CAAR) represents the average total effect of the event across all firms, thus:

$$CAAR_t = \sum_{i=\pm jt}^{n} AAR_i \quad (4)$$

To determine the significant value of the CAAR for the selected event windows, one sample t-test is conducted.

4. Results and Discussion

To determine the impact of the election day on the Malaysian stock market, specific events before and after the election day was chosen to be a selected event window. The results of the CAAR and the *t*-statistic for each of the selected event windows are presented in Table 2.

Prior to election day all selected event windows show positive CAAR with significant t-value at 1 per cent level, respectively. The beginning of the official 11-day campaigning period shows the highest CAAR for pre- announcement event windows. This finding shows that the market reacts to the event and respond to the political uncertainties causing asset prices to change. For post-election event windows, only one window shows negative CAAR which is at day 4 with -0.82 per cent with significant t-value at 1 per cent level. The negative CAAR may results from the shock election win made by the new government. Another seven selected event window shows positive CAAR with significant t-value at 1 per cent level, respectively. The positive and significant value of CAAR point out that investors are reacting to the successful implementation of the key promises made by the new government and absorbed the new information effectively. These findings support results found by Smales (2014) which reported that the political uncertainty surrounding elections can give impact on the stock market and would result in higher levels of market uncertainty and vice versa. Moreover, the finding found by Brown *et al.* (1988, 1993) which states that immediate price

changes induced by either favourable or unfavourable events will be followed by positive returns during the post-event period.

Table 2: CAAR and the *t*-statistics for the selected event windows

	Event windows	Events	CAAR	*t*-statistic
Pre-Election	t_{-29}	Prime Minister Najib Razak tabled the Election Commission's redelineation report in Dewan Rakyat	0.59	-39.9862**
	t_{-22}	Formal dissolution of Parliament	3.84	-36.2578**
	t_{-6}	Official 11-day campaigning period begins	3.91	-14.1214**
	t_{-2}	Early voting begins	3.04	-6.7860**
Post-Election	t_{+4}	Stabilise the price of petrol and introduce targeted petrol subsidies	-0.82	-32.0001**
	t_{+11}	Initiate a comprehensive review of all mega projects that have been awarded to foreign countries	1.00	-11.3689**
	t_{+13}	Abolish the Goods and Services Tax (GST) and take steps to reduce the cost of living	0.79	-13.3023**
	t_{+29}	Postpone repayment of Perbadanan Tabung Pendidikan Tinggi Nasional (PTPTN) for all graduates whose salaries are below RM4,000 per month and abolish the blacklisting policy	8.00	-7.6125**
	t_{+35}	Set up Royal Commissions of Inquiry on 1Malaysia Development Berhad (1MDB), Federal Land Development Authority (FELDA), Majlis Amanah Rakyat (MARA) and Tabung Haji, and to reform the governance of these bodies	5.57	-6.5518**
	t_{+48}	Set up a Special Cabinet Committee to properly enforce the Malaysia Agreement 1963	2.79	-7.8044**
	t_{+60}	Abolish unnecessary debts imposed on FELDA settlers	0.38	-10.0518**
	t_{+65}	• Equalise the minimum wage nationally and start the processes to increase the minimum wage • Introduce Employees Provident Fund (EPF) contribution for housewives	2.91	-11.0116**

Notes: ** Denotes statistical significance at 1 per cent level.

The finding found in this study also consistent to the EMH which stated share prices reflect all available information (Fama *et al.*, 1969) and prices will change in response to new information. The announcement of the successful or unsuccessful of the key promises and the events before the pooling day refer to the new information that might affect the financial market and economic uncertainties as a whole. Hence a political regime change is the key event that would create economic uncertainties and give impact to the share prices as new information is absorbed by the market.

Figure 2 shows FBMKLCI, AAR and CAAR for 656 companies for the period of 95 active trading days, (t_{-29}, t_{+65}) and separates the AAR and CAAR for pre and post-election day, respectively. The highest CAAR is 8.40 per cent at day 29 after announcement and the lowest is -3.33 per cent at day 7 prior to the announcement. On day 29 after election day, the good news absorbed by the market whereby the new government successfully fulfil one of the important promises which is postponed the repayment of PTPTN for all graduates whose

salaries are below RM4,000 per month and abolish PTPTN's blacklisting policy. The lowest CAAR may results from the nomination process and beginning of official 11-day campaigning period. A key campaign issue in GE14 was influential of the media social (Welsh, 2018). This include its synergies with political advertising.

Figure 1: FBMKLCI, AAR and CAAR for companies listed in Bursa Malaysia for 95 active trading days

The trend reveals that positive abnormal returns before election days which started from day 29 until two days before the election day was significant to the news released on 10 April 2018 (21 active trading day prior to event) by the Election Commission chairman Hashim Abdullah which announced that the general election will took place on Wednesday, 9th May 2018. Investors respond negatively to the news that polling day will fall during a weekday and detect suspicious agenda in the selection of polling date. This is in line with findings found by Brown *et al.* (1988, 1993) which states that the market reacts randomly to information and asset prices may not reflect all available information instantaneously.

Day 5 after the election day marks as a turning point for positive abnormal returns. This shows that investors react to the events and news spread in the market and start trading actively. This led the price to increase with investors earning positive returns. Increases in expected returns are directly linked to increases in stock variability induced by the events themselves (Brown *et al.*, 1988, 1993). Then two days after the announcement on the set up Royal Commissions of inquiry on 1MDB, FELDA, MARA and Tabung Haji and to reform the governance of these bodies was made, the CAAR start to decline drastically. This could be due to the heavy scandal in these institutions (including money-related issues) which give negative perception to the investors and they absorbed the information negatively. More than that, the market under pressure impacted by the new government's 100-day election manifesto (which is due on 17 August 2018). The investor perceived the news negatively and create a panic market by their judgment. According to Brown *et al.* (1988, 1993) short-run behaviour of stock prices following unexpected and substantial news announcements does not reveal evidence of anything but rational judgment by investors. The degree of selling pressure during

the campaigning period and the poll results may affect the stock market's performance post-election (NST Business, 2018, April 9). Additionally, the stock market investors expect the ruling Barisan Nasional to win comfortably in GE14. This could be the reason stock prices fluctuate, sometimes rapidly and dramatically, due to unexpected poll results.

In Figure 2, it is also evident that post-election day, FBMKLCI performed opposite to CAAR from t_3 to t_{57}. As stated earlier, FBMKLCI comprises of 30 of the largest companies in the stock market and it appears that the change in ruling government, as well as the introduction of new policies by the new government is perceived as negative news by investors, therefore a negative impact can be seen by the reduction in the value of 30 of the largest companies in Bursa Malaysia but the impact is not the same to the other 656 actively traded companies.

5. Conclusion

The aim of this study was to find the impact of a political announcement i.e. the results from the GE14 (which resulted in a regime change) on share price and the length of time that is needed for the market to adjust to the announcement. Similar to Pantzalis *et al.* (2000) and Ahmed (2017), we find there is significant abnormal return on the selected event windows for both pre and post-event day. This study also finds that the market reacts to the events and new information released within two to five days prior to the announcement of the event.

It can also be concluded that post-election announcement, the impact of a political regime changes to the stock market based on FBMKLCI is not reflective with CAAR of actively traded stocks in the Bursa Malaysia. The index appears to have a negative reaction to the political regime change while actively traded stocks in Bursa Malaysia experienced significantly positive CAAR.

Moreover, a 100-day benchmark or 67 active trading days is insufficient for the market to recover from a political regime change as the stock market appears to be experiencing volatility during the observation period. It is recommended for future studies to utilise event periods of longer than 67 observation days to see the length of time needed for the stock market to fully adjust to the news.

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Effects of Venture Capital, R&D, and Technology on IPO Underpricing: Evidence from China

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Abstract: Research Question: This study is a preliminary attempt to investigate the effects of technology and R&D expenditure and the moderating effect of venture capital through the interaction of technology and R&D on the underpricing of IPOs in China's A-share market. **Motivation:** The role of technology in IPO underpricing and the moderating influence of venture capital, R&D, and technology on underpricing of IPO have not been studied; thus, this research aims to fill this gap. **Idea:** High-tech firms experience higher IPO underpricing. Venture capital can help to reduce the high-technology IPOs' underpricing by reducing the uncertainty associated with tech-IPOs. IPOs with higher R&D expenditure experience higher IPO underpricing. Venture capital can help release the uncertainty faced by IPOs with high R&D and reduce the underpricing of such IPOs. **Data:** The data represent all IPOs in China's A-share market from SSE and SZSE for the 2013–2018 period. Our sample includes a total of 997 IPOs, excluding financial company IPOs and IPOs without integrated data. **Method/Tools:** We apply a cross-product residual centering approach to explore the relationships among factors. **Findings:** We find that venture-backing IPOs experience less underpricing, technology requirement increases IPO underpricing, and R&D expenditure helps to reduce tech-IPO underpricing. The striking observation that has emerged from the data is that IPO underpricing caused by technology requirement can be moderated by the participation of venture capital. The finding highlights that strengthening the supervision role of venture capital in the invested company and improving the R&D information disclosure level in a technology company can effectively reduce the degree of IPO underpricing. **Contributions:** Our research focuses on all IPOs from China's A-share market, indicating an expanded sample size. More importantly, this study offers new insights by illustrating the interaction effect between R&D and technology on IPO underpricing as a means of explaining the moderation influence of venture capitalists on IPO underpricing.

Keywords: Initial public offering, venture capital, technology, R&D expenditure, underpricing, VC-backed IPO.
JEL Classification: G20, G23, G24

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1. Introduction

Initial public offering (IPO) underpricing has generated significant interests of practitioners. Since Ibbotson (1975) discovered this phenomenon for the first time in 1975, many scholars have studied stock markets in different periods and different regions and found that IPO underpricing is a highly usual phenomenon in all capital markets all over the world, but the degree of underpricing is different. Usually, IPO underpricing in a developing country's stock market is more serious than those in developed countries. Most of models and theories account for the phenomenon based on information asymmetry and agency theory.

The role of government has led China's IPO market to manifest certain characteristics with respect to other stock markets. The China Securities Regulatory Commission plays an essential role in the IPO pricing process. China's domestic research on IPO underpricing is mainly divided in two parts. Jiang *et al.* (2014) combined China's institutional background to investigate IPO underpricing, showing that institutional factors are the main reason for the high underpricing of IPO in China. Meanwhile, Su (2004) followed the Western research approach and suggested that the level of information asymmetry also significantly affects the level of underpricing of China IPOs.

Among the factors that influence IPO underpricing, R&D expenditure, venture capitalists, and technology have been widely examined by some scholars. Research and development (R&D) expenditure is considered a high-risk investment and is a discretionary strategy. R&D expenditure is especially crucial for IPO firms because IPO firms are mostly young and entrepreneurial and because IPO underpricing is related to R&D intensity (Kao and Chen, 2020). For the research on USA-listed companies, Heeley and Jain (2007) and Guo *et al.* (2006) found that an increase in R&D expenditure leads to changes in IPO underpricing in the same pattern. According to Guo *et al.* (2006), R&D (i.e., intangible assets) causes IPO underpricing because accounting assessment methods restrict R&D expenditure on financial statements. Following agency theory, Jensen and Smith (2000) demonstrated that some managers may increase their own compensation by engaging in R&D expenditure. Consequently, R&D not only can improve the future value of a company but also bring extra costs. Venture capitalists not only provide money for a startup but also bring more lasting influence on the portfolio company. According to Megginson and Weiss (1991), venture capital likely monitor the performance of firm managers to certify the true value of companies and reduce IPO underpricing. The "grandstanding hypothesis" theory proposed by Gompers (1996) suggests that VCs would like to afford the underpricing cost because the good reputation of the VC is essential in future undertakings. Lowry and Schwert (2002) indicated that a high degree of information asymmetry usually exists in technology IPOs, and this phenomenon causes a relatively huge IPO underpricing.

Using Chinese data from 30 October 2009 to 31 December 2012, Han and Shen (2017) finds that R&D information disclosure level and R&D market mispricing both have an essential influence on IPO underpricing, while venture capital functions only as a signal, not as information, hence leading to a higher degree of IPO underpricing. Using Chinese data, Zhou and Sadeghi (2019) investigate R&D spending, characterized by information asymmetry and valuation uncertainty, which can aggravate IPO underpricing. Conversely, they found a positive signal effect for patents which may significantly reduce the extent of IPO underpricing. Using Chinese firms, Peng *et al.* (2021) examine the impact of strategic customer alliances (CSA) on IPO underpricing from 2007 to 2015. Their core findings suggest that IPO firms with CSAs have less IPO underpricing than those without such a relationship.

Chin *et al.* (2006) and Guo *et al.* (2006) explored the relationship between R&D expenditure and underpricing of IPO. Megginson and Weiss (1991) investigated the relationship between venture capitalists and IPO underpricing. Jiang *et al.* (2014) examined the role of VCs in China listed companies. However, the role of technology in IPO

underpricing and the moderating influence of venture capital, R&D, and technology on underpricing of IPO have not been studied; thus, this research aims to fill this gap. Moreover, this study examines the impacts of R&D on IPO underpricing with the reciprocal effects of venture capitalists and technology. The research questions include as to whether the correlation between R&D and IPO underpricing and the correlation between technology and IPO underpricing are influenced by venture capitalists and whether technology requirement or R&D expenditure cause the interaction between R&D expenditure and technology.

On November 5, 2007, the most profitable company in Asia, PetroChina, returned to the A-share. The initial return of the company peaked at 163%, but its stock price gradually dropped after the IPO, depreciating by 76% in only over three months. As a result, a large amount of PetroChina shareholders experienced huge losses. In China's A-share market, companies in IPO (e.g., PetroChina) are common. By studying 570 A-share IPOs in China, Chan *et al.* (2004) found that the average underpricing for A-share is 178%. With respect to the venture capitals in developed countries, the venture capital in China is in the development stage, with small scale and insufficient standardization (Han and Shen, 2017). Therefore, whether China's venture capital can provide effective support and services for enterprises is unclear and deserves a detailed study. In addition, an increasing number of high-tech firms have emerged in China and helped in the country's economic growth. Thus, China's A-share market provides a good data sample for the research.

By using the cross-product residual centering methodology to study a sample of 997 China A-share IPOs in 2013–2018, we find that venture capital plays a moderating role on tech-IPO underpricing. The result illustrates that tech-IPOs experience higher underpricing. Meanwhile, although R&D expenditure does not assert influence on underpricing, it increases the underpricing rate of technology IPOs. This study also brings new insights into the existing literature, as it can demonstrate the interaction effect between technology and venture capitalists.

This study is the first one to examine the effects of venture capital backing, technology background, and R&D on IPO underpricing and the interaction relationships among them in China. Previously, Western researchers investigated the role of venture capital, R&D, and high-tech level on the underpricing of IPOs in mature stock markets. By contrast, the Chinese stock market is not mature enough. Moreover, given the government and institutional factors, the Chinese stock market will most likely show a different Situation. In addition, Chinese researchers who explored the R&D and venture capital effects on IPO underpricing based on the data from China Growth Enterprise Board found considerable uncertainties on the interaction effects of technology and venture capital, R&D and venture capital, and technology and R&D on IPO underpricing; these points are explained in our study. Our research also discusses the moderating effect of venture capitalists rather than focusing only on the independent effects of the aforementioned three factors. Our results suggest that technology has a positive relationship with IPO underpricing, whereas venture capitalists tend to reduce the positive effect. Moreover, for technology IPOs, the higher is the investment in R&D expenditure, the higher is their underpricing.

The remaining part of the paper is organized as follows. Section 2 presents the literature review and the developed hypotheses. Section 3 introduces the empirical methodology and results. Section 4 discusses and analyzes the results. Our conclusion is drawn in Section 5.

2. Literature Review and Hypothesis Development

2.1 IPO Underpricing

In a prior study, Chin *et al.* (2006) and Guo *et al.* (2006) explore the relationship between R&D expenditure and IPO underpricing. Their result indicates that innovation capital, such as R&D spending, award patent, and patent citations, can be treated as the signals of IPO

underpricing. Companies with higher R&D expenditure experience severe underpricing. Megginson and Weiss (1991) investigate the certification role played by VCs in IPOs and find that venture-backing companies have a remarkable lower first-day return. In a study of the role of VCs in small- and medium-sized enterprise IPOs, Jiang *et al.* (2014) conclude that venture capitalists appear to have an important function in facing asymmetries of capital markets. However, no study has examined the moderating effect of VCs through the interaction of technology and R&D on the underpricing of IPOs in China's financial market.

Ibbotson (1975) demonstrates that a particular character of IPOs leads to a significant positive initial return in IPO. Ritter (1991) finds the average IPO initial return to be 14.3% for the 1526 IPOs sampled between 1975 and 1984. The method of developing information asymmetry hypotheses is the most popular approach to explain IPO underpricing. Rock (1986) suggests that information asymmetry appears between acquainted and uninformed investors. Underwriters have to underprice IPOs to hold uninformed investors. Beatty and Ritter (1986) states that the uncertainty on IPOs decides the degree of underpricing: when the unsureness is higher, the expense of accessing information is higher, and thus, the underpricing will be higher.

2.2 China Stock Market

China established the Shanghai Securities Exchange (SSE) in 1990 and the Shenzhen Stock Exchange (SZSE) in 1991, the two stock exchanges in the country. Each of them serves as a main board. Unlike other countries' stock markets, the China stock market is distinct in several aspects. First, the outstanding shares have segmented ownership, which can be classified as state-owned shares, personal-owned shares, and publicly shares. Second, the China stock market is separated as A- and B-share markets. Third, the cycle between offering and listing is usually long in the China stock market. Moreover, state-owned shares account for a large proportion before and after a company goes public. These features render this study on the China stock market meaningful and unique.

China's IPO system has experienced several stages in the past three decades. From 1990 to 1995, the China Securities Regulatory Commission claimed that regulators would have to decide which company can go public at a proposed offer price under the strict IPO listing quota system. From 1995 to 2000, the China Securities Regulatory Commission required the P/E multiple of an IPO firm to not exceed 15. This restriction resulted in an extremely high over-subscription rate and huge IPO initial returns. Since 1999, the commission applied a new market-oriented system, in which the lead underwriters will initially identify a price range, then the offer price will be determined by means of individual investor transaction within the range. However, this method has caused high P/E ratios in the stock market. Since 2006, the book building approach with a "window guidance" has set the P/E multiple to an upper limit of 30. Since 2012, this approach has required an IPO firm's P/E ratio to be below 25% of the average P/E multiple of the industry peers. Thereafter, the IPO pricing system in China has formally shifted to one with a market orientation (Jiang *et al.* 2014).

2.3 Hypothesis Development

2.3.1 Technology and IPO Underpricing

According to Ritter (1991), the IPO underpricing phenomenon occurs in many countries. Chen *et al.* (2007) finds that the average IPO underpricing in the A-share market is 178%, which is significant. In developed capital markets, on average, IPOs are underpriced by around 15%. In emerging markets such as Malaysia, the ratio is over 80%, whereas in China, it sometimes reaches 200%, according to the China Center for Economic Research (CCER) database (Wang *et al.*, 2018). Information asymmetry is usually applied to explain the underpricing. Lowry and Schwert (2002) demonstrate that high-technology IPOs tend to have

higher underpricing because they usually take higher risk for investors. The serious underpricing in high-technology IPOs is connected with the company's future growth opportunities (Lowry and Shu, 2002). Chen *et al.* (2007) has proven the argument of Lowry and Schwert (2002) and suggest that the IPOs of high-technology firms experience higher underpricing in the Taiwan stock market than those in the other industries. On the basis of the above information, this study hypothesizes the following:

H_1: High-tech firms experience higher IPO underpricing.

2.3.2 Venture Capital, Technology, and IPO Underpricing

Venture capital is considered a widely used financial channel and well suited for the creation and business growth. According to Hellmann and Puri (2000), venture capital is used to invest in corporate equity, provide value-added service for the firm's development, and pursue high returns. Several prior studies investigate the impact of venture capital attributes on firm performance (Gompers, 1996; Gompers and Lerner, 2004; Chemmanur *et al.*, 2011). They found that four main features are widely confirmed that account for the firm-level change of investment target. These are VC investment amount, VC shareholding ratio, the VC institution's age, and the number of VC institutions involved in holding shares. According to Barry *et al.* (1990), venture capital equips a monitor function on a firm's manager as a means of certifying the portfolio's value. Megginson and Weiss (1991) demonstrate that VCs have a certification role, which increases the firm value, lessens the information asymmetry, and reduces the underpricing of IPOs. As the uncertainty about the future is high, high-technology IPOs need to undergo underpricing. However, venture capitalists can provide the assistance to decrease the uncertainty, therefore reducing the underpricing. Subsequently, we develop our second hypothesis based on the abovementioned information.

H_2: Venture capital can help to reduce the high-technology IPOs' underpricing by reducing the information asymmetry and further uncertainty associated with tech-IPOs.

2.3.3 R&D and IPO Underpricing

Aboody and Lev (2000) claim that the fundamental reason of information asymmetry is R&D expenditure. Guo *et al.* (2006) confirm the statement, arguing the R&D expenditure is the primary source of the asymmetry. By using evidence from Taiwan, Chin *et al.* (2006) support Guo *et al.* (2006) argument and show that IPOs with large R&D expenditure are underpriced higher because of the financial information asymmetry, which is a result of innovation capital standards. Therefore, we present the following hypothesis:

H_3: IPOs with higher R&D expenditure experience higher IPO underpricing.

2.3.4 Venture Capital, R&D, and IPO Underpricing

R&D is strongly related with patent count (Hausman *et al.* 1984). The patents statistic is one of the measurements that can help to decide whether R&D expenditure is effective. According to Chin *et al.* (2006), pre-IPO R&D, number of awarded patents, and patent citations are related with IPO underpricing. Although R&D brings with it asymmetry information and increases the risk faced by investors, thus reducing a firm's value, patent citations can help to increase firm value at some point. Loughran and Shive (2011) state that companies owning more granted patents usually attract venture capitalists and receive more funds, while venture capital can stimulate the innovations of companies. Gomez-Mejia *et al.* (2003) suggest that VCs play a supervisory role in monitoring the changes between the R&D expenditure and performance of firms. The level of participation of venture capitalists implies the true worth

of the R&D, which is to reduce the asymmetric information resulting from R&D. Therefore, we present the following hypothesis:

H_4: Venture capital can release the uncertainty faced by IPOs with high R&D and reduce the underpricing of such IPOs.

3. Research Methodology

3.1 Data Source and Sample

The data represent all IPOs in China's A-share market from SSE and SZSE for the 2013–2018 period. Our sample includes a total of 997 IPOs, excluding financial company IPOs and IPOs without integrated data. Chi and Padgett (2005) have implied the absence of significant contradictions in the underpricing degree between the two stock exchanges. The IPO data index covers company name, lead underwriter, offer price, offer date, offer size, turnover rate, industry sector, offer to first close, filing date, firm age, revenue, and R&D expense. The data were obtained using *Wind*, which is China's leading financial terminal. The data of the IPOs with venture capital investment background were acquired from the *China Venture* database. Data analysis was performed using *Stata 15.1 SE*.

3.2 Measurement of Variables

This study follows the method of Lu *et al.* (2012) of measuring the dependent and independent variables to test the effects of R&D, venture capital, and technology on IPO underpricing. IPO underpricing *(MAR)* is calculated using the formula of first-day closing price minus offer price divided by the offer price.

$$MAR = \frac{P_{NH} - P_F}{P_F} \tag{1}$$

where P_{NH} denotes the first-day closing price, and P_F represents the offer price.

3.2.1 Market Returns Before IPO Filing Date (MKT), Turnover Ratio (TURV), Offer Size (PROCEED), Underwriter Reputation (UNDR) and IPO Firm Age (AGE)

Lowry and Schwert (2002) depict investors as individuals usually concerned with IPO offer price based on public information, such as the market situation prior filing date. Following the method of Lu *et al.* (2012), we use the CSI 300 index of 30 days before filing date to represent the stock market condition before an IPO. The CSI 300 index is a component stock index compiled from 300 A-share companies selected from the Shanghai and Shenzhen stock markets. It covers approximately 60% of the market capitalization of SSE and SZSE and has good market representation.

$$MKT = \frac{I_F - I_{F-30}}{I_{F-30}} \tag{2}$$

where I_F represents the market index on filing date, and I_{F-30} is the market index 30 days before filing date.

Turnover ratio *(TURV)* is the ratio of the first-day trading volume to the total number of shares issued on the IPO day. It is the frequency at which shares change hands in the market in the first day. This variable demotes the degree of an investor's recognition of the stock value in the secondary market. On the basis of the study of Su (2004), we consider the IPO turnover rate to be controlled when examining the underpricing rate.

$$TURV = \frac{The\ first\ day\ trading\ volume}{Number\ of\ outstanding\ shares} \quad (3)$$

Considering that information asymmetry is not only caused by R&D, Lu *et al.* (2012) use offer size, underwriter reputation, and firm age as control variables. Offer size has been proven to be related to IPO underpricing; when the offer size is larger, the risk of asymmetric information is smaller, and the IPO underpricing is lower (Beatty and Ritter, 1986). The logarithm of IPO proceed denotes *PROCEED*. *PROCEED* equals to offer price multiply by number of shares issued.

Carter and Manaster (1990) assert that if the underwriter has a higher reputation, it can reduce information asymmetry to a certain degree. Han and Shen (2017) also use underwriter reputation as a dummy control variable to examine the R&D, venture capital, and IPO underpricing of the China Growth Enterprise Board. Following the work of Han and Shen (2017) based on the underwriter ranking of Bloomberg, we define the top 10 underwriter as underwriter reputation (*UNDR)* equals one, zero otherwise.

Prior research indicates that the longer a company is existing, the more effective the market can assess its performance, therefore decreasing information asymmetry. Following the research of Lu *et al.* (2012), we apply the logarithm of years from a firm's establishment to the IPO filing date plus 1 as a proxy variable.

3.2.2 Venture Capital (VC), Demand on Technology (TECH) and R&D Intensity (RD)

If an IPO is venture-backing, then venture capital *(VC)* equals one, zero otherwise. Following Lu *et al.'s* (2012) model, we use a technology industry dummy variable as a proxy. Demand on technology *(TECH)* equals one if an IPO is in the technology sector according to Bloomberg's categories, zero otherwise. Following the method of Lu *et al.* (2012) as cited in Wallin and Gilman (1986), we use the ratio of R&D expense to sales at the time before issuing to value the company's R&D. This variable is defined as

$$RD = ln\left(1 + \frac{RDE}{SALES} \times 100\right) \quad (4)$$

where *SALES* and *RDE* are the sales and R&D expense of a year prior to the IPO. If the R&D and sales data a year before issuing are unavailable, then the data two years prior to issuing date are used.

3.3 Empirical Model

This study applies the cross-product residual centering methodology which was used by Lu *et al.* (2012) to examine the moderating effects of VCs in Taiwan's IPO underpricing. The benefit of using this methodology is the elimination of the multicollinearity phenomenon in the regression analysis model. To explore the moderating influence on the relationship between the independent and dependent variables, we use the interaction terms among the variables in the model. This lightening effect is reflected by the interaction terms. However, if a correlation exists between the main and cross-product variables, then we consider multicollinearity to often occur at this time. Therefore, applying the cross-product residual centering approach would be helpful in obtaining highly accurate results.

Regression (5) mainly examines the effect of the control variables on IPO underpricing, including market conditions, by using the CSI 300 index at 30 days before filing (*MKT)*, turnover rate (*TURV*), IPO age (*AGE*), IPO proceeds (*PROCEED*), and underwriter reputation (*UNDR*).

$$MAR = \alpha_0 + \alpha_1 MKT + \alpha_2 TURV + \alpha_3 AGE + \alpha_4 PROCEED + \alpha_5 UNDR + \varepsilon \quad (5)$$

In an attempt to explore the independent influences of the abovementioned three variables on underpricing, we apply regression (6) containing the moderating variables, venture capital background (*VC*), technology sector dummy (*TECH*), and R&D expenditure (*RD*).

$$MAR = \beta_0 + \beta_1 MKT + \beta_2 TURV + \beta_3 AGE + \beta_4 PROCEED + \beta_5 UNDR + \beta_6 VC + \beta_7 TECH + \beta_8 RD + \nu \quad (6)$$

Regression (7) introduces the interaction variable of tech-IPO and venture capitalist as a means of exploring whether the use of VC can lessen the uncertainty faced by a technology company and subsequently reduce the tech-IPO underpricing.

$$MAR = \gamma_0 + \gamma_1 MKT + \gamma_2 TURV + \gamma_3 AGE + \gamma_4 PROCEED + \gamma_5 UNDR + \gamma_6 VC + \gamma_7 TECH + \gamma_8 RD + \gamma_9 VC \times TECH + \mu \quad (7)$$

Regression model (8) is used to investigate whether a venture capitalist can bring with it an inverse effect on IPO underpricing if the R&D expenditure would cause a higher underpricing.

$$MAR = \lambda_0 + \lambda_1 MKT + \lambda_2 TURV + \lambda_3 AGE + \lambda_4 PROCEED + \lambda_5 UNDR + \lambda_6 VC + \lambda_7 TECH + \lambda_8 RD + \lambda_9 VC \times TECH + \lambda_{10} VC \times RD + \upsilon \quad (8)$$

Regression (9) includes all of the independent variables and interaction terms, and it is used to examine whether the demand on technology can reduce the information asymmetry led by R&D and subsequently decrease the IPO underpricing of firms with high R&D expenditures, or inversely, i.e., whether high R&D expenditure can remit the information asymmetry caused by technology and lower the tech-IPOs' underpricing.

$$MAR = \theta_0 + \theta_1 MKT + \theta_2 TURV + \theta_3 AGE + \theta_4 PROCEED + \theta_5 UNDR + \theta_6 VC + \theta_7 TECH + \theta_8 RD + \theta_9 VC \times TECH + \theta_{10} VC \times RD + \theta_{11} TECH \times RD + \omega \quad (9)$$

4. Empirical Results

4.1 Descriptive Statistics and Correlation

Table 1 presents the descriptive statistics for all of the variables. Column 1 of Table 1 lists the dependent and independent variables. The average IPO underpricing in China is 43.9%, which significantly higher by 10%–20% than the IPO underpricing level in mature capital markets. The average turnover rate is at a low value of 0.7%, indicating that the speculation phenomenon is not obvious in this sample stock market. The rational investment greatly reduces the IPO underpricing. The minimum IPO proceed is 78.3 million RMB, whereas the maximum proceed is 27120.41 million. The difference is large, which implies that the IPO scale is noticeably different from those in China's mainboard stock market. This fact may be explained as the A-share market covering all of types of industries, and industry differences are usually huge. The same reason can also explain the difference between firm age, as the industries and development stages of the listed companies on the mainboard market are scatter and not concentrated.

Table 1: Descriptive statistics for the independent variables used in the multiple linear regressions

Variable	Mean	Std. Dev.	Min	Max
MAR	0.439	0.014	0.136	0.460
MKT	−0.017	0.058	−0.202	0.260
TURV	0.007	0.050	0.000	0.844
PROCEED (in mil RMB¥)	577.975	1095.704	78.300	27120.430
UNDR	0.493	0.500	0	1
AGE (in year)	14.226	5.459	3	55
VC	0.573	0.495	0	1
TECH	0.220	0.414	0	1
RD	1.609	0.595	0.000	3.661
N	997	997	997	997

Table 2 shows the correlation among the variables. Turnover rate is significantly and negatively related with underpricing. The IPOs with a higher turnover rate are less underpriced (*TURV* = −0.049). An underwriter with good reputation brings more proceed for IPOs. Firm age can be treated as a factor reflecting IPO underpricing; that is, an older company usually has a higher underpricing level (*AGE* = 0.067). In addition, VC-backing IPOs experience lower underpricing (*VC* = −0.114), suggesting that venture capital can help to reduce the underpricing phenomenon. Following Lewis *et al.* (2003), a simple bivariate correlation is used in this study to determine the existence of relationships between two different variables, such as tech-IPO and non-tech IPO. It shows how much tech-IPO will change when there is a change in non-tech IPO. We find that Tech-IPOs have higher underpricing compared with non-tech-IPOs (*TECH* = 0.083). The technology industry often represents a high-risk industry, a scenario that explains why investors are more confident with non-tech-IPOs and prefer low-risk IPOs.

Table 2: Correlations for the independent variables used in the multiple linear regressions

Variables	*MAR*	*MKT*	*TURV*	*PROCEED*	*UNDR*	*AGE*	*VC*	*TECH*	*RD*
MAR	1								
MKT	−0.033	1							
TURV	−0.469***	0.110***	1						
PROCEED	−0.112***	0.028	0.042	1					
UNDR	−0.005	−0.017	−0.033	0.129***	1				
AGE	0.067**	0.039	−0.082***	−0.085***	−0.075**	1			
VC	−0.114***	0.065**	0.018	0.016	−0.023	−0.052*	1		
TECH	0.083***	−0.017	−0.037	0.018	0.048	−0.082***	0.047		
RD	0.042	0.000	−0.032	−0.108***	0.020	−0.026	0.055*	1	1

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 2 also shows that underwriter reputation is higher in younger firms than that in older firms (*AGE/UNDR* = −0.075). Companies with venture capital background and belong to the high-tech industry are younger firms. Venture-backing IPOs provide higher R&D (*RD/VC* = 0.055), verifying that venture capitalists prefer to invest in companies with high R&D. R&D also has a significant positive relationship with technology (RD/TECH = 0.381), which is common in the technology industry. High-tech companies have to invest more money in R&D compared with non-tech companies.

4.2 Main Results

After conducting the moderating regression model, we obtain the empirical result. This Table 3 combines five regression models, as previously demonstrated, and investigates the effects of the control variables, VC background, technology requirement, and R&D expenditure on IPO underpricing and their interaction terms.

Table 3: Results of moderating linear regression between IPO underpricing and the independent variables

Variables	(1)	(2)	(3)	(4)	(5)
MKT	0.006	0.007	0.007	0.007	0.007
	(0.937)	(1.050)	(0.976)	(0.971)	(0.970)
TURV	−0.126***	−0.126***	−0.126***	−0.126***	−0.126***
	(−16.361)	(−16.192)	(−16.199)	(−16.205)	(−16.198)
LAGE	0.002	0.002	0.002	0.002	0.002
	(1.407)	(1.376)	(1.414)	(1.371)	(1.377)
PROCEED	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
	(−2.959)	(−2.849)	(−2.943)	(−2.931)	(−2.934)
UNDR	−0.000	−0.000	−0.000	−0.000	−0.000
	(−0.076)	(−0.098)	(−0.083)	(−0.045)	(−0.059)
VC		−0.003***	−0.002**	−0.004*	−0.004
		(−3.960)	(−2.454)	(−1.657)	(−1.634)
TECH		0.003**	0.005***	0.006***	0.005
		(2.527)	(3.395)	(3.474)	(1.385)
RD		−0.000	−0.000	−0.001	−0.001
		(−0.355)	(−0.443)	(−0.860)	(−0.871)
VC × TECH			−0.004**	−0.005**	−0.005**
			(−2.298)	(−2.416)	(−2.408)
VC × RD				0.001	0.001
				(0.764)	(0.746)
TECH × RD					0.000
					(0.168)
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000
Obs.	997	997	997	997	997
Adj-R^2	22.99%	23.99%	24.32%	24.28%	24.21%

Notes: *** p<0.01, ** p<0.05, * p<0.1. T-values are in parentheses. *LAGE* is defined as the logarithm of the firm age from startup to going public plus 1. The interaction terms are the products of two independent variables.

Table 3 presents the effect of technology, R&D, and VC dummy on IPO underpricing and their cross-product terms. The control variables include market index, shares turnover ratio, firm age, IPO proceed, and underwriter reputation. The coefficient associated with TURV variable (−0.126) is negative and significant ($P < 0.01$, $t = -16.361$) in column 1 of Table 3. This reveals that the turnover ratio is negatively correlated with IPO underpricing, which means that the higher is the turnover ratio, the lower is the underpricing rate. This finding was unexpected and implies that when new shares are traded more frequently on the secondary market, the closer the first day's closing price is to the offer price, and the lower the underpricing rate. The coefficient associated with PROCEED variable (−0.002) is also negative and significant ($P < 0.01$, $t = -2.959$) in column 1 with underpricing. This result suggests that when the offer size is larger, the effect of information asymmetry is smaller, and the lower is the underpricing.

The coefficient associated with VC variable (−0.003) is negative and significant ($P < 0.01$, $t = -3.960$) in column 2 of Table 3. This result indicates that a venture capitalist can cut down the IPO underpricing. The coefficient associated with TECH (−0.005) is positive and significant ($P < 0.01$, $t = 3.395$). This finding suggest that the technology company has a higher underpricing because such type of firm has to take more risk that what is common in the technology industry. This result confirms hypothesis 1.

However, RD is not significant with IPO underpricing ($t = -0.355$), which rejects hypothesis 3. During the data collection process, we used the R&D and sales figure from one year before the issuing date for the IPOs in 2013–2016. The R&D and sales number at one year before issuing date for the 2017 and 2018 IPOs were unavailable. Thus, we calculated RD by using two years before IPO date for the R&D and sales of the 2017 and 2018 IPOs.

The interaction term VC × TECH was added in the third model. The result is presented in Column 3 of Table 3. The tech-IPO experiences a much greater underpricing (t = 2.527). The VC × TECH variable has a significant negative relationship (t = −2.298) with the dependent variables, which demonstrates that VC has a moderated effect on tech-IPO underpricing, reducing the uncertainty faced by technology companies. This fact verifies hypothesis 2. Column 4 of Table 3 indicates that the cross-term VC × RD (t = 0.764) is not significant, which means that venture capital has no direct moderating effect on the relationship of R&D expense and IPO underpricing. Hypothesis 4 regarding the VC and R&D does not appear to be well grounded. Column 5 of Table 3 shows that TECH × RD (t = 0.168) is not significant with underpricing. Thus, RD does not have the moderating effect on the relationship of technology firms and IPO underpricing.

According to the above analysis, R&D expenditure does not have a significant influence on the underpricing of IPOs in China's A-share market. Subsequently, we further develop the sub-group analysis by examining the relationship of R&D and IPO underpricing in the technology and non-technology sectors. Table 4 presents the effect of technology on the relationship of R&D and IPO underpricing. The control variables are market condition, turnover rate, age of IPO firms, IPO proceeds, underwriter reputation, venture capital dummy, and RD intensity. Column 1 of Table 4 lists the tech-IPOs, in which R&D has a significant negative relationship at t = −2.313. However, R&D does not have any effect of non-technology IPOs with respect to the underpricing (t = −0.671). Therefore, the greater is the R&D expenditure, the smaller is the degree of underpricing in the technology industry. For the high-tech companies, the disclosure of R&D expenditure will affect the judgement of investors.

Table 4: Sub-analysis of the effect of technology on the relationship between R&D spending and IPO underpricing

Variables	*TECH*	*NON-TECH*
MKT	−0.001	0.006
	(−0.840)	(0.712)
TURV	0.087***	−0.128***
	(20.652)	(−14.635)
LAGE	−0.000	0.002*
	(−0.702)	(1.679)
PROCEED	−0.000	−0.002***
	(−1.163)	(−3.074)
UNDR	−0.000	−0.000
	(−0.089)	(−0.180)
VC	−0.000**	−0.000
	(−2.087)	(−0.097)
RD	−0.000**	−0.001
	(−2.313)	(−0.671)
Prob>F	0.0000	0.0000
Obs.	219	778
Adj-R^2	66.64	23.94

Notes: *** p<0.01, ** p<0.05, * p<0.1. T-values are in parentheses. *LAGE* is defined as the logarithm of the firm age from startup to going public plus 1. The interaction terms are the products of two independent variables.

Overall, after examining the five regression models, we can demonstrate on the basis of Table 3 that the turnover rate has very significant relatively with underpricing (t = −16.361). Popular new stock trading in the secondary market can help to reduce the information asymmetry, therefore considerably lessening the underpricing of the IPOs. Table 3 also shows that proceed has a negative relationship with underpricing (t = −2.959), implying that the large

scale of IPOs will reduce the underpricing degree. Column 2 of Table 3 suggests that venture capitalists can help to release the IPO underpricing, thus confirming the hypothesis 1. The second model similarly highlights that tendency of technology to facilitate IPO underpricing. Column 3 of Table 3 shows that venture capitalists can bring with it a moderated effect on the IPOs in the technology industry. The VC × TECH variable is negatively significant at t = −2.298, given that TECH is positively significant (t = 3.395). Columns 4 and 5 of Table 3 illustrate that R&D expenditure does not affect IPO underpricing. The R&D effect on the technology–underpricing relationship is analyzed accordingly. The result shown in Table 4 conveys that a greater R&D expenditure can decrease the underpricing in the technology sector (t = −2.313).

5. Discussion

Our research objective is to investigate the moderating effect of VCs through the interaction of technology and R&D on the underpricing of IPO in China's A-share market. The detailed research questions attempt to explore as to whether technology firms experience much higher IPO underpricing and whether venture capital can help to reduce the underpricing effect on tech-IPOs. Then, we test whether high R&D intensity IPO experience higher IPO underpricing and whether venture capital can help lessen the effect. For the result, this study expects that tech-IPOs and high R&D IPOs will experience much higher underpricing. Moreover, the study predicts that the use of venture capital will alleviate the IPO underpricing caused by technology and venture capital can reduce the uncertainty faced by high-R&D IPOs, subsequently reducing the underpricing. The actual result thoroughly confirms hypothesis 1. Interestingly, the result we obtained concerning the second hypothesis was unexpected. R&D does not have any correlation with IPO underpricing based on the regression model result. However, on the basis of the sub-analysis, we propose that R&D has a significant correlation with underpricing for technology companies. Griliches (1998) commented that a company's R&D expenditure level is positively correlated with the company's future value. For high-tech companies, such an influence is more obvious than that in non-tech firms. The evaluation of R&D expenditure efficiency needs to be analyzed in conjunction with the industry's competitive environment, operating conditions, and national industrial policies. However, most investors do not have the professional knowledge and the information research ability. Thus, an increase in R&D expenditure will increase the level of information asymmetry between the issuer and the investors.

Although our result regarding R&D and IPO underpricing differ from those of Lu *et al.* (2012) and Han and Shen (2017), it can be argued from several points. Fu *et al.* (2011) explored whether R&D investment level affects IPO underpricing, as with Chen *et al.* (2007); both studies selected the IPOs of growth enterprise market (GEM) as their samples. By contrast, we selected the companies listed in the mainboard of the China stock market. Fu *et al.* (2011) claimed that the mainboard listed companies generally include R&D investment in management expenses and rarely offer separate disclosures or incomplete disclosures. Second, industry and company size have a significant impact on the company's R&D expenditure. The mainboard listed companies have relatively fragmented industries, whereas the GEM listed companies have similar sizes and concentrated industries. Therefore, the A-share mainboard IPO sampling increases the error caused by the difference in industry and company size.

With respect to the other previous studies, our study has generated consistent results and also contradicting aspects. First, Lu *et al.* (2012) suggested that IPOs with technology have a greater degree of underpricing, and the emergence of venture capitalist can moderate the positive correlation between underpricing and high technology in the Taiwan stock market. This finding is consistent with our result. Second, Han and Shen (2017) commented that their

empirical result does not support the expectation that venture capital has an adjustment relationship between R&D investment and IPO underpricing. A reasonable explanation would be that the level of venture capital involvement in GEM is not high enough. Third, in the study on R&D and IPO underpricing in GEM, Fu *et al.* (2011) stated that R&D investment level is positively related to IPO underpricing. This point validates that as the R&D expense increases, the information asymmetry between issuers and investors will significantly improve. Our conclusion is inconsistent with this result concerning R&D.

It is plausible that a number of limitations may have influenced the obtained result. To begin with, we selected China's A-share mainboard IPOs as our sample. As most of the companies in the mainboard are already mature enough, the influence of R&D and venture capital may not be huge. Second, we did not add the company's return on equity and capital structure as the control variables, which are related with the valuation of the company from investors. Additionally, for the VC variable, we did not include VC-equity stakes, venture capitals' size, and reputation index; we only considered the presence of venture capital. Data collection is further required to determine exactly the relationship between venture capital and IPO underpricing. Another possible source of error is we did not consider the effect of market fluctuation on IPO underpricing when we designed the model, and we did not use the adjusted underpricing rate.

5.1 Reliability and Validity

Apart from the slight discrepancy, given the research method and the sample collection technique, our research remains to be reliable and valid. First, the following evidence proves the internal validity: Lu and Chen (2012) confirmed the relationship among venture capital, technology, and R&D expenditure with IPO underpricing in the Taiwan stock market. We applied a similar model in our research and adjusted the model by considering the special situations in the China stock market. The adjustments were based on Han and Shen's (2017) empirical study on R&D, venture capital, and IPO underpricing from GEM IPOs.

Second, the external validity can be demonstrated as follows. The sample of our study covers 2013–2018 and all of China's A-share IPOs, excluding the finance companies. The sample size consisted of 997 IPOs, which was larger than the sample size in the existing similar studies. All of the data were mainly collected from Wind, which is China's leading financial terminal. This fact can guarantee the accuracy of the collected data. In summary, our research model can fit most capital market types at some point, and our study is reliable.

Third, we analyzed the variance inflation factor statistics and examined the multicollinearity among variables. Excluding the interaction terms, the mean VIF is 1.045, which is below 10. After adding VC, TECH, and RD, the mean VIF is 1.089 and remains below 10. This result confirms that multicollinearity does not exist in our model, and our finding is substantial.

Table 5: Variance inflation factor for the control variables and all variables

Variables	Control variables only		All variables	
	VIF	1/VIF	VIF	1/VIF
MKT	1.019	0.981	1.024	0.977
TURV	1.035	0.966	1.037	0.964
LAGE	1.023	0.978	1.036	0.966
PROCEED	1.082	0.924	1.126	0.888
UNDR	1.066	0.938	1.072	0.932
VC			1.013	0.987
RD			1.217	0.822
TECH			1.184	0.845
Mean VIF	1.045	.	1.089	.

5.2 Theoretical Contribution

Numerous studies have examined the roles of venture capital, technology, or R&D on IPO underpricing, but most of the samples had been on the Western stock market, such as those of Italy and Germany. Meanwhile, a number of published Chinese papers have explored the effects of R&D and venture capital on IPO underpricing based on the data from the China Growth Enterprise Board. Our research focuses on all IPOs from China's A-share market, indicating an expanded sample size. More importantly, this study offers new insights by illustrating the interaction effect between R&D and technology on IPO underpricing as a means of explaining the moderation influence of venture capitalists on IPO underpricing.

6. Conclusion

The most popular theory to explain IPO underpricing is the uncertain future value and information asymmetry. Technology companies have the characteristics of high risk and high return, which brings the uncertainty to the companies' future value. The intervention of venture capital is a good approach to reduce information asymmetry. The China IPO market grows rapidly, which provides a good data sample for exploring the relationship among venture capital, R&D, and technology on IPO underpricing. This study uses the cross-product residual centering approach to build the regression model, in which market condition, offer size, firm age, underwriter reputation, and IPO turnover rate are included as the control variables. Then, the products of VC and TECH, VC and RD, and TECH and RD are added as the interaction variables. The evidence from this study suggests that tech-IPOs experience much higher underpricing, while R&D expenditure does not assert influence on the underpricing, which may contribute to the possibility of having different R&D disclosure levels in the mainboard market, but R&D will increase the underpricing rate for technology IPOs. Moreover, this study contributes new insights by illustrating the interaction effect between technology and venture capitalist and by explaining the moderation influence of venture capitalist on IPO underpricing. For the finance market, the result indicates that if a company had venture capital investment before listing, the risk associated with operation or finance will be less. Also, in order to reduce IPO underpricing, financial regulator should try to reduce the information asymmetry that between public and companies. However, this study does not explore the same relationship in China's stock GEM and small- and medium-sized enterprise board, and our model design does not consider the influence of capital market fluctuations on IPO underpricing. Further research is needed to study the different stock market boards in China, apply the market-adjusted IPO underpricing, and consider the venture capitals' share percentage of IPO companies and venture capital reputation in the research model.

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Effect of Minimum Tick Size Policy on Price Efficiency and Execution Cost

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Abstract: Research Question: Whether the minimum tick size has effect on small caps price efficiency and execution cost on the Indonesia Stock Exchange (IDX). **Motivation:** The market microstructure of the Indonesia Stock Exchange (IDX) is based on the emerging market-order driven system which is different than developed market and identified by the problem of inefficiency market. The previous related literatures to minimum tick size policy are only limited to the concept of liquidity and the bid-ask spreads (Bessembinder, 1999; Goldstein and Kavajecz, 2000; Ekaputra and Ahmad, 2007). We propose a new empirical model using Market Efficiency Coefficient (MEC) approach as the only proxy of the price efficiency, Price Inefficiency (PINE) to measure the level of price inefficiency level, and Execution Cost (COST) to measure the probability of error pricing in stock trading. This empirical model is applied to the testing of the effectiveness of minimum tick size policy and its impact on stock trading efficiency. **Idea:** Based on the empirical research literature, the minimum tick size policy will increase the price efficiency and reducing the execution cost for some of the securities transactions, then the execution cost can also be minimalized to create a beneficial transaction. **Data:** We collect the daily stock price trading, intraday price trading, and trading volume from Regular Board (RG) and RTI data recording. **Method/Tools:** We run the Ordinary Least Square (OLS), Quintile Regression as robust test, and General Linear Model to test the empirical model. **Findings:** We find that the minimum tick size insignificantly effects price efficiency and partially affects execution cost. The minimum tick size significantly affects mean of execution cost, but insignificantly affects median of execution cost. We also find that insignificant difference of small caps price efficiency level between pre-implementation of the minimum tick size and post-implementation of the minimum tick size and significant difference of execution cost level between pre-implementation of the minimum tick size and post implementation of the minimum tick size**. Contributions:** Our research contributes to develop a robust empirical model to analyse the impact of market microstructure policy.

Keywords: Minimum tick size, price efficiency, price inefficiency, execution cost, IDX.
JEL classification: G00, G14, G19.

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1. Introduction

Price of securities traded in the stock exchange is basically determined by the analyst investors on the various types of information available to assess the value of the traded securities. This fact revealed that the investor's ability to analyze information will greatly affect the efficiency of the securities price. However, different investors respond differently to a particular information available, resulting in dispersion of information in determining the price of the securities (Chordia *et al.*, 2008).

Furthermore, the information of a certain securities will determine the efficiency of transaction activities as a whole. Thus, the transaction that contain more relevant information on the valuation of an asset will lead to an efficient price of the securities traded, however the investors still have different preferences and valuation of the securities traded price (Camelia and Vasile, 2012). Nevertheless, trading securities are not necessarily able to provide all the relevant information, causing the price of securities to be less efficient. This causes traded securities to bear an execution costs. This kind of execution cost is a hidden cost generated from the mechanisms and conditions (rules) of the transactions (Hasbrouck and Schwartz, 1988).

One of the provisions related to the transaction securities is the tick size policy. Tick size is the minimum variance stated through stock exchanges policy to limit the rate of variation of stock price on each of transaction activity. Tick size consists of two types of systems namely single tick size system and multi-tick size system (Chiang *et al.*, 2001). The policy of tick size in Indonesian is aimed to create a fair and efficient trading activity as well as to improve the liquidity of the securities in the capital market. In addition, tick size policy is also expected to increase the interest of the investors to be involved in the capital market transaction.

In addition to smooth the securities transactions, Indonesia Stock Exchange (IDX) also applies JATS (Jakarta Automatic Trading System). JATS works in two trading sessions in the stock exchange. The first session takes place from 09:00 am until 12:00 pm on Monday to Thursday and from 09:00 pm until 11:30 pm on Friday. While the second trading session takes place from 13:30 am until 16:00 pm on Monday to Thursday and from 14:00 pm until 16:00 pm on Friday. Securities purchase in the first session will not be amended and withdrawn before it enters the second trading session, in which in the second trading session, the purchase order of the securities from the first session will be expired, so that in the second session, there will not be any purchase order securities.

Announcement of change in tick size of securities or stock is treated as the guidelines for the investor in transacting the securities, in which this tick size policy is considered to increase the efficiency of trading activities which is characterized by the increased of securities trading liquidity and volume. Tick size policy is also expected to attract investors and the public to participate in securities transaction (Ekaputra and Ahmad, 2007). The practice of tick size policy has been previously used by a number of international capital markets. American Stock Exchange reduces the tick size policy from $1/8 to $1/16 to the stock price below US$5 in August 1992 and under US$10 in February 1995 and eventually tick size policy applies to all securities in March 1997. Different from AMEX, Singapore Stock Exchange (SSE) reduced the tick size policy from 50 cents to 10 cents for the stock, whose price is more than 25 dollars in July 1994. Subsequently, the Toronto Stock Exchange also reduced the tick size policy from CS$0.125 to CS$0.05 for the stock whose price is traded at CS$5 and reduced the tick size policy from CS$0.05 of into the CS$0.01 for the stock whose price is from 10 cents to 50 cents on December 4th, 1996. A number this tick size policy practices was successful in increasing securities trading activities in trading through the increase of trading volume and price discovery. The decline of tick size policy is considered highly beneficial to investors due to the fact that higher tick size policy could

limit the price that was set by traders which will restrict price competition between investors and traders. With a smaller tick size policy, then the price competition among the liquidity providers will be increased, so that the market order trade (liquidity demanders) will benefit from this narrowing spreads (Wu *et al.*, 2011). Since the market order can take advantage of this, then the investor is expected to be interested to buy (sell) stocks. Different from the many of previous researches, this study focuses on the effect of the minimum tick size policy on the price efficiency and the execution cost. Price efficiency is often assumed as an instrument for traders to allocate their funds on investments that will generate an optimum return.

In addition, this study will contribute to the minimum tick size policy from at least five major approaches. First, this study is in relation to emerging order which is structurally different from the developed markets in the Asia-Pacific region. Second, the previous related studies about minimum tick size policy are only limited to the concept of liquidity and the bid-ask spreads (Bessembinder, 1999; Goldstein and Kavajecz, 2000; Ekaputra and Ahmad, 2007). Third, this study focuses on low cap stocks (small caps) which are rarely traded and usually transacted at an inefficient price. Fourth, previous studies only use Market Efficiency Coefficient (MEC) approach as the only proxy of the price efficiency, but in this study, inefficiency price proxy is also used in order to avoid ambivalent theoretical approach. Fifth, this study is involved in more well established testing, not only limited to the testing of effectiveness of minimum tick size policy, but also on the impact of policies on trading efficiency. This tick size policy is expected to increase the efficiency of small caps indicated by a substantial increase in liquidity trading activities (Chordia *et al.*, 2008). In this way, the minimum tick size policy will increase the price efficiency and reducing the execution cost for some of the securities transactions. Thus, the execution cost can also be minimalized to create a beneficial transaction.

2. Literature Review

2.1 Price Efficiency, Execution Cost and Tick Size

The price discovery of stocks trading is generated by the market price matching process (Schreiber and Schwartz, 1986), the collecting and implicitly interpreting to the trading information (Baillie *et al.*, 2002) and the accommodation of information from trading activities to the stocks market price (Lehmann, 2002). Generally, the observed assets price could be categorized into two main components, i.e. the assets which indicate common price efficiency dispersion and assets which extend in trading transition process related to bid-ask spreads change, liquidity and price rounding. For that, assets price will be efficient within fundamental value and investor expectation revision. For that, the price adjustment to the trading information will causes the increasing of price efficiency (Fama *et al.*, 1969). Then, securities trading volume indicates market's respond to a trading information when the investors improve their activities in securities trading according to analytic projection on financial data forecasting which are available to their investment risks.

The price adjustment including trading volume movement is a result of investor's valuation to the securities fair price. Generally, the investors which are involved in assets valuation consist of informed traders and uninformed traders. Informed traders have information related to underlying assets probability distribution which contain future price and they take the bargaining position according to the information. But, uniformed traders invest without any ability to collect the information and depend on securities price observation (Grossman, 1976).

Investors should collect overall information which is related to stocks trading and recommend it to the market trading (Asquith *et al.*, 2005). Some of traders generate important information in the trading activity and reduce asymmetric information to

securities price (Green, 2006). The information usually is generated on the trading days in constant level. Most of the information is public information and other else private information (Jones *et al.,*1994). The investors contribute to analyses the value of price as information intermediation. Information dispersion can be obtained through investors action in market activity and securities price, whom investors should have invested to the predictable securities and the investors knowledge to the securities are restricted. Investors will depend on the information availability to a security and the investors have various information preferences.

Investors as cause of restriction information availability are categorized into two main types. i.e. securities information observers and common traders. The first investors only involved in fundamental private trading assets and the second investors only involved according to securities price movement. The first investors trade according to private fundamental information, because the information is dispersed restrictedly in the information observers and some of investors who hold valid information will receive trading profit and some else obtain the benefit of undershoot trading and reactively affect to long term trading.

Although, investors are not always obtaining the information perfectly and the most of investors often valuate partially the trading information which generate the price would be pressured (Barberis *et al.*, 1998). Although, according to investor's behavior concept, investor's resistance to valuation deviation in the price securities as results of investors that ignore evaluation and validation of securities information (Dische, 2002). Commonly, price efficiency depends on information which is contained in investor's trading activity. In securities trading, the securities information is dispersed to all of investors through the pricing system. Higher securities price that is generated by pricing system in stocks trading contain more securities price information (Grossman and Stiglitz, 1980). However, the stocks trading generate the informational excess of prices efficiency as the cause of investor's overconfidence in stocks trading valuation without validate and hold the less accurate pricing of information (Grossman, 1976). The condition might be caused the trading volume excessively increase (Odean, 1998). But, usually also causes undershoot trading which reduces utility expectation and costly information.

Principally, the security trading information will be inseminated to all traders followed by stocks trading price change and price adjustment (Fama *et al.*, 1969). Commonly, the investor's preference to trading information is related to analysis forecasting dispersion and analysis forecasting ranges which indicate investor's expectation heterogeneity. Then, the total of analysts is indication of information dispersion where investors try to obtain accurate information in stocks price valuation.

Insider traders as informed traders have access better information rather than common investors. But the insider traders would be disturbed the trading activity e.g. (1) It reduces liquidity of trading, (2) preserve managerial incentive and (3) an assumption of unfairness and loss of investor confidence of capital market. Some others evidence suggests that the insider trading leads to more informationally efficient stock price. In another aspect, informed traders are risk neutral and they strategically influence the price. Variance of liquidity increasing leaves the information efficiency of prices unchanged as response to liquidity trading. When traders observe an increase in the number intensifies trading competition between them, it leads to the market efficiency. But, risk averse informed traders are less aggressive in respond an increasing in liquidity trading. Even information acquisition is exogenous, variance of liquidity trading increasing decreases price efficiency. This cause of marginal effect of number informed traders increasing on market liquidity to be negative despite greater competition between the traders. Short horizon return predictability is diminished by arbitrage trading especially in effective market liquidity. It is

caused as impact of varying liquidity over time and market turbulent and effective trading cost improvement and liquidity decline or even disappears (Chordia *et al.*, 2006).

The informed investors constantly and strategically observe price deviations and place orders to exploit the deviations, thereby market systems become more efficient, investors will obtain even from smaller price deviations, also increasing the efficiency of the markets. They analyze the price stocks according to the information of fundamental value of securities. The informed traders affect stock price through their trading. Price becomes increase when informed traders buy it and decrease when they sell it. When informed traders accurately estimate the securities price, it will improve price efficiency (Zhao and Chung, 2006).

Execution cost is a hidden trading cost. Generally, execution cost is generated by trading activity as causes of some factors like price movement, *bid-ask spreads* more than tick size and error in pricing (Hasbrouck and Schwartz, 1988). Execution cost generates the expansion of return variance for the short term. If the stock informationally efficient without any execution cost, MEC will be greater than one. For that, the decreasing of execution only impact to the small caps traders (Porter and Weaver, 1997).

Tick size is minimum price change unit which and regulated according to specific multiples and important market protocol (Chiang *et al.*, 2001). Tick size consists of single tick size system and multiple tick size system. Partially stock exchanges use single tick size system which is bearsed to the all stock price ranges and multiple tick size system which a number of tick size are pointed to different price ranges (Chung *et al.*, 2011). As a stock exchange authority polish, tick size regulation related to trading activity. Tick size polish will be impact to the price efficiency and reduce execution cost (Van Ness *et al.*, 2000). Minimum tick size will improve public investors to participated in the stock trading activity.

2.2 The Effect of Minimum Tick Size on Price Efficiency and Execution Cost

Trading liquidity is closely related to the price efficiency of the securities, in which the more liquid trading is assumed to support the trading efficiency through the increase in prices of securities, narrowing bid-ask spreads and an increase in the volume of trading activities (Hasbrouck and Schwartz, 1988). One of the policies associated with the increased in trading liquidity is the minimum tick size policy (Chung *et al.*, 2011). Minimum tick size policy might seem to have an impact on a certain price range characterized by informational securities trading (Angel, 1997). Information on securities trading activity is positively related to the trading efficiency (Porter and Weaver, 1997). This is due to the minimum tick size that can affect the efficiency of the price through trading liquidity (Chordia *et al.*, 2008).

The securities price will only be efficient if all information is included in the determined traded securities price. In addition, the minimum tick size policy can also affects the efficiency of the price through trading liquidity. Despite all of these matter, minimum tick size policy in some extend might also affect the price inefficiency, whereby the minimum tick size policy affects the decreasing of variance ratio (Ekaputra and Asikin, 2012).

H_1: Minimum tick size effects on the small caps price efficiency.

Execution costs occur in the short term volatility, indicated by a number of factors such as the limitation of ordered record (limit order) and the sequence of information arrival that resulted in inaccuracies of price determination, so the prices can only reach a relatively low adjustment. Basically a high execution costs are concentrated to the stocks that are less in number and more liquid in transaction (Griffiths *et al.*, 2000). So the execution cost and the price of such securities is very much influenced by or dependent on the tick size, to which

the minimum tick size is considered to encourage investors to increase trading activity and make the execution cost of the transaction becomes substantially reduced (Kuo *et al.*, 2010). Additionally, minimum tick size might also have an impact on the execution cost for traders who transact at the relatively higher stock price (Hasbrouck and Schwartz, 1988).

H_2: Minimum tick size affects the execution cost.

2.3 The Difference Level of Price Efficiency and Execution Cost Between Old Tick Size Period and New Tick Size Period

There are some indications that the level of efficiency of the securities price after minimum tick size policy is implemented is greater than before the policy is implemented, that indicates the informational efficiency of securities (Kuo, 2010; Kurov, 2008).

H_3: There is a difference in the level of small caps price efficiency rates between old and new tick size period under the control of closing price, variant returns and trading volume.

Execution costs thoroughly increased after the tick size policy is implemented, especially for traders who expect on the liquidity. If the low order execution costs (less than 1,000 sheets) decreases, the execution cost of large orders (more than 100,000 copies) will increase , resulting in the increase of average execution cost. Because of this, tick size policy will result in a lower execution costs (Jones and Lipson, 2001).

H_4: There is a difference in the level of execution costs between old and new tick size periods under the control of closing price, variant returns and trading volume.

3. Methodology

This research is event study research which restrictively involves some of sources to singular entity according to space and time horizon (Getz, 2014). The objects of research include tick size as categorical data, price efficiency and execution cost. The type of data in this research is panel data or pooled data that is the combination of time series data and cross section data. The data used in this study involved the daily stock closing price, intraday price data per 30 minutes and the volume of daily transactions. Source of data used comes from the records of Indonesia Stock Exchange (IDX). Data resources consist of transaction data on Regular Board (RG) and recording data of RTI. Observations in this research are differed into old tick size period and new tick size period within 30 transaction days for each period. Old tick size period begins from November 11th, 2013 to December 20th, 2014 and new tick size period begins from January 13th, 2014 to February 25th, 2014. This research includes early period beginning after a week minimum tick size policy to avoid non-trading days.

Population of the research data consist of all listed stock of Indonesia Stock Exchange (IDX). Then, we only select 37 samples that had been selected were used in this study as can be seen from the table below:

Table 1: Sample selection process

No.	Sample Criteria	Total
1.	Securities that are fully traded in old and new tick size period.	98
2.	Securities that are always traded in average price of Rp200,- to less than Rp500 both in old tick size period and new tick size period.	80
3.	Securities which are not affected by *corporate action.*	78
4.	Above average securities trading value	37
	Final Sample	37

Furthermore, to construct the dependent variable of price efficiency, we use Market Efficiency Coefficient (MEC) as price efficiency proxy. MEC relates to stocks price for each a half hour is assumed as short term volatility as implicated by long term volatility. MEC is derived according to the fact that stock price is involved through accumulation of return on *T* period as explained:

$$\frac{P_T}{P_0} = \frac{P_1}{P_0} \times \frac{P_2}{P_1} \times \ldots \times \frac{P_t}{P_{t-1}} \tag{1}$$

The accumulation of log short term return, long term return is obtained as explained in the equation:

$$R_L = \sum_{T-1}^{T} R_{S,t} \tag{2}$$

If stock price informationally efficient and assumed that stock return is identically and independently distributed, long term variance return will be equal to the total of shorter return variance as explained here:

$$\text{Var } R_L = \sum_{T-1}^{T} \text{Var}\left(R_{S,t}\right) = T\left(\text{Var}(R_S)\right) \tag{3}$$

The use of this MEC is intended to determine the short-term price changes on the long-term price changes. MEC can be measured from the ratio of long-term variance returns in relation to the volatility of short-term return (Hasbrouck and Schwartz, 1988)

$$\text{MEC} = \frac{\text{Var}R_L}{T(\text{Var}R_s)} \tag{4}$$

However, the use of the MEC as a proxy for the price efficiency is still ambiguous. Perfect MEC value is equal to one. Sometimes the value of MEC can be increased from less than one to more than one, which means that there exist a switch of securities trading conditions, from overaction to underreaction. Then, the higher frequency of trading will improve the value of MEC more than one (MEC > 1). It will generates that the market trading is in overreaction of price discovery. Otherwise, the lower frequency of trading will reduce the value of MEC less than one (MEC < 1). It implies that the market trading is underreaction of price discovery (Ekaputra and Asikin, 2012).

To anticipate the problem of trading volatility, the Price Inefficiency (PINE) approach is used, which is the absolute deviation value of one, as shown as follows (Ekaputra and Asikin, 2012).

$$\text{PINE} = |\text{MEC} - 1| \tag{5}$$

Less efficient trading will cause an execution costs. Execution costs are the hidden costs that come from securities transactions due to some factors such as the increase in price, widening of the bid-ask spreads and trade protocol. Execution costs can be calculated by the derivation of MEC value. If the MEC value is less than one, then the equation is as follows:

$$C = [1 - MEC(VarR_s)]^{\frac{1}{2}} > 0 \quad (6)$$

Whereas if the MEC is greater than one, then the equation is as follows:

$$C = [MEC - 1(VarR_s)]^{\frac{1}{2}} < 0 \quad (7)$$

The execution cost will be negative when the MEC is greater than one. In the economics context, the negative execution cost shows that a certain party in the capital market is subsidizing the transaction. This party might be a trader who does not have information, thus offering bid for the old price limit or might also a trader who sell stock inefficiently (Ekaputra and Asikin, 2012).

The independent variables that will be used in this research is a dummy variable (DUMMY) which equal to 1 for the period after the implementation of the minimum tick size policy and is 0 for the period prior to the implementation of the minimum tick size policy. In addition, a control variable is also used, that consists of the average closing price (PRICE), variance returns (VARIANCE) and trading volume logs (VOLUME). The equation used as following (Porter and Weaver, 1997; Ekaputra and Asikin, 2012).

$$MEC_{it} = \beta_0 + \beta_1 PRICE_{it} + \beta_2 VARIANCE_{it} + \beta_3 VOLUME_{it} + \beta_4 DUMMY_{it} + \varepsilon_i \quad (8)$$

$$PINE_{it} = \gamma_0 + \gamma_1 PRICE_{it} + \gamma_2 VARIANCE_{it} + \gamma_3 VOLUME_{it} + \gamma_4 DUMMY_{it} + \varepsilon_t \quad (9)$$

$$COST_{it} = \delta_0 + \delta_1 PRICE_{it} + \delta_2 VARIANCE_{it} + \delta_3 VOLUME_{it} + \delta_4 DUMMY_{it} + \varepsilon_t \quad (10)$$

The equation models based on the theoretical assumptions of market microstructure model development:

1. Price stock indicates attention of investor analyst and market participants. The higher attention of investor analyst and market participants implies the high dispersion of information in the trading (Ekaputra and Asikin, 2012).
2. Long term variance return reflects information revelation for long time period. Short time variance returns are expected to cause excessive volatility which is observed as error pricing. Then, the long term variance returns which reflect information revelation will indicate the value of variance ratio of long term variance returns to short term variance returns. (Hasbrouck and Schwartz, 1988; Ekaputra and Asikin, 2012).
3. Long term variance returns will increase the execution costs which imply that the information is costly (Hasbrouck and Schwartz, 1988; Ekaputra and Asikin, 2012).
4. Volume of trading measures the arrival of utilitarian traders which is identified as non-driven traders. It generates uninformed trading which increase price inefficiency and execution cost (Cramton, 1997; Ekaputra and Asikin, 2012).

Furthermore, we run OLS regression and Quintile regression to test the effect of minimum tick size on price efficiency and execution cost. Quintile regression is employed as robust test because of small sample size (Ekaputra and Asikin, 2012). Then, we run GLM (*General Linear Model*) to test the difference of price efficiency and execution cost between old tick size period and new tick size period.

4. Result and Discussion

The following statistical description shows the difference between the old tick size period, and the tick size period on the price efficiency, price inefficiency, execution cost, price, variant returns and volume.

Table 2: Descriptive statistic

	MEC	PINE	COST	PRICE	VARIANCE	VOLUME
Old Tick Size Period						
Mean	0.419	0.588	0.014	340.8	0.0007	18.97
Median	0.396	0.604	0.016	332.6	0.0003	19.22
Maximum	1.135	0.961	0.026	485.5	0.0135	21.75
Minimum	0.039	0.135	-0.008	208.4	0.0000	13.81
Std. Dev.	0.197	0.173	0.006	73.15	0.0022	1.87
Obs.	37	37	37	37	37	37
New Tick Size Period						
Mean	0.397	0.610	0.021	325.8	0.0006	18.98
Median	0.320	0.682	0.020	323.3	0.0005	18.84
Maximum	1.069	0.996	0.050	490.2	0.0046	22.25
Minimum	0.004	0.050	-0.005	217.8	0.0000	13.99
Std. Dev.	0.241	0.222	0.012	63.84	0.0008	1.95
Obs.	37	37	37	37	37	37

Table 2 shows that the average value and median of MEC in new tick size period decrease from 0.419 and 0.396 to 0.397 and 0.320. The average and median of PINE in new tick size period increase from 0.588 and 0.604 to 0.610 and 0.682. It implies that the price efficiency of new tick size period decrease, then the price inefficiency of new tick size period increase due to the low liquidity observed than the average decline in trading transaction. Meanwhile, the mean and the median value of execution costs in new tick size period increases from 0.014 and 0.016 to 0.021 and 0.020. This indicates that execution costs increase quite dramatically so that trading activities is becoming costly. The mean and median value of PRICE in the new tick size period decreases from 340.8 and 332.6 to 325.8 and 323.3. It indicates the lower analyst and market participant intention in new tick size period. The mean and median of VARIANCE in the old tick size period change from 0.0007 and 0.0003 to 0.0006 and 0.0005. The mean of variance returns decreases slightly, but the median of variance returns improves well. The mean and median value of trading volume on the old tick size period is 18.97 and 19.22, while on the new tick size period they are changed to 18.98 and 18.84. The arrival of utilitarian traders in mean of trading volume increases slightly, but the median of trading volume decreases.

Furthermore, we run OLS, Quintile Regression, and GLM which show statistical results in Table 3. Table 3 shows that the minimum tick size policy affects positively on the MEC but not significant either by OLS or Quintile regression analysis tool. This indicates that the minimum tick size policy insignificantly improves mean and median of price efficiency. It indicates that minimum tick size policy is unable to improve the stocks liquidity which reflects the problem of volatility returns. The problem of volatility returns indicates the higher price liquidity but lower price efficiency, than it will generate an overreaction stocks price trading. Similarly, GLM analysis shows that there are no significant differences in the level of the MEC between the old tick size policy and new tick size policy. In these problems, we should observe the effect of stock trading quality indicators which consist of average stock price, variance returns, and trading volume. Price of stocks insignificantly improves mean and median of price efficiency. It indicates insignificant analyst and market participant attention to be involved in stocks trading. The lower attention of analyst and market participant reflects asymmetric information problem among traders. Informed

traders generate higher abnormal returns rather than uninformed traders. Meanwhile, the variance returns significantly improves the mean and median of price efficiency. It implies that the higher information revelation indicates lower hidden action problem and the information is costly. Subsequently, the trading volume significantly reduces the mean of price efficiency, but insignificantly reduces the median of price efficiency. The higher arrival of utilitarian traders significantly will increase uninformed trading activity and reduce price efficiency significantly in mean of stocks trading, but insignificantly in median of stocks trading. It indicates that the uninformed trading impacts on higher hidden information problem. The higher uninformed trading will impact on inefficient trading which indicates the higher cost of transaction including information cost and execution cost. The price equilibrium of stocks is stick to be changed quickly due to costly trading information.

Table 3: The result of first equation

Independent Variables	Expected Sign	Analysis Tools		
		OLS	QR	GLM
Intercept	None	-13.759*	-12.001*	18.348*
Price	+	0.124	0.096	1.312
Variance	+	19.318*	16.822*	18.262*
Volume	-	-0.416*	-0.307	7.460*
Tick Size	+	0.011	0.021	0.329
$F_{statistic}$		5.917*	-	-
Quasi LR-(Stat)		-	15.587*	-
R^2		0.255	-	-
Pseudo R^2		-	0.155	-
Adjusted R^2		0.212	0.106	0.212

Notes: *) Significant at 1%.

Table 4 shows that the minimum tick size policy negatively affects the price inefficiency, but not significant based on the results of the OLS regression and Quintile Regression (QR) analysis, as well as the analysis of covariance using the General Linear Model (GLM) that we do not find any significant difference at the level of inefficiency price (PINE) between old and new tick size period. This indicates that the minimum tick size policy insignificantly reduces the mean and median of price inefficiency. It means that minimum tick size policy is unable to reduce uninformed and speculative trading activity which is indicates stocks error pricing. The informed traders receive abnormal returns from inefficient trading activity, meanwhile the trading activity will be costly. Furthermore, we should observe the effect of stock trading quality indicators which consist of average stock price, variance returns, and trading volume. Price of stocks insignificantly reduces the mean and median of price inefficiency. It indicates the problem of asymmetric information in trading activity which reflects the lower attention of analyst and market participant in stocks trading. Meanwhile, variance returns significantly reduces mean of price efficiency, but insignificantly reduce median of price inefficiency. It implies that the higher information revelation indicates lower hidden action problem in mean of price inefficiency, but higher hidden action problem is still occurred in median of price inefficiency. Subsequently, the trading volume significantly improves the mean and moderately improves median of price inefficiency. It indicates that the arrival of utilitarian traders significantly impacts on higher uninformed trading which reflects higher hidden information problem. The higher uninformed trading also indicates the problem of price inefficiency which implies on higher cost information in trading. The dispersion of trading information will be dispersed slowly and the information will be scarcely to be accessed in trading activity. The price equilibrium

will be stickily changed to the subsequent information arrival in trading activity. The evidence of stickily price proves the theory of market microstructure of costly information trading activity which contradicts Hypothesis Market Efficient assumptions.

Table 4: The result of second equation

Independent variables	Expected Sign	Analysis Tools		
		OLS	QR	GLM
Intercept	None	-0.107	-0.293	0.180
Price	-	-0.000	-0.000	1.395
Variance	-	-53.018*	-43.891*	16.644*
Volume	+	-0.035*	-0.027**	9.360*
Tick Size	-	-0.011	-0.050	0.076
$F_{statistic}$		-5.739*	-	-
Quasi LR-(Stat)		-	14.758*	-
R^2		-0.255	-	0.250
Pseudo R^2		-	-0.148	-
Adjusted R^2		-0.206	-0.099	0.206

Notes: *) Significant at 1%, **) Significant at 10%.

Table 5 shows that the minimum tick size policy partially reduces the execution cost. The minimum tick size policy affects significantly the mean of execution costs, but insignificantly affects the median of execution cost. This suggests that the traded securities on the mean (average) is experiencing a very low response towards the information, resulted the investors to trade at a price that does not match with the information for some of the securities and invest inefficiently. It also implies that the trading information is costly and price stocks will be stick to be changed in price equilibrium. The stock price will be slowly changed to the arrival of new information revelation due to costly trading information. Similarly, information used by most corporate investors and traders are not well distributed or absorbed by all investors. In addition, the analysis of GLM covariance shows that there are significant differences between the level of execution cost within the old and new tick size period.

Table 5: The result of third equation

Independent Variables	Expected Sign	Analysis Tools		
		OLS	QR	GLM
Intercept	None	-0.008	-0.007	0.191
Price	-	-0.000*	-0.388	10.107*
Variance	+	-1.204**	-1.197	3.531**
Volume	+	-0.002*	-0.001	7.656*
Tick Size	-	-0.006*	-0.005	8.813*
$F_{statistic}$		-7.726*	--	-
Quasi LR-(Stat)		--	18.257*	-
R^2		-0.309	--	0.309
Pseudo R^2		--	-0.168	-
Adjusted R^2		-0.269	-0.121	0.269

Notes: *) Significant at 1% , **) Significant at 10%.

5. Conclusion

The statistical testing on minimum tick size policy is aimed to create a fair and efficient stock transaction. Minimum tick size policy will be supported by the investors through their willingness to increase the transaction volume. Minimum tick size policy affects positively on the price efficiency, but the effect is not significant. This is due to the low level of securities trading transactions caused by the low trade capitalization among the informed

investor and low support from securities traders to increase the value of trade transactions. It leads to the information related to securities are restricted by insider investors, causing the securities to be traded at prices that are not relevant.

Furthermore, the minimum tick size policy partially effects on the execution cost, the minimum tick size policy affects the mean execution costs significantly, but insignificantly affects the median of execution cost. These evidences may indicate that the security information partially absorbed leads to only a fraction of investors get the benefits of the information while the other investors go on transacting at an unfair and inefficient price caused to generate a reasonable execution cost. In addition to the results, the investors are intended to take some benefit from their responses on the arrival of new information.

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Exchange Rate Dependency Between Emerging Countries-Case of Black Sea Countries

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Abstract: Research Question: This study tries to answer the following question, Does exchange rate shocks on one of the Black Sea countries affect the neighbour's countries' currencies. **Motivation:** Many different financial crises that afflicted the countries of the Black Sea region over different periods and thus affected their exchange rate. **Idea:** Hence, this study examines the existence of currency dependency in the form of a geographical pattern in the Black Sea countries and tests. The study measures the cross-market dependency by looking for significant dependency in the tails; any significant dependency reflects the co-movement in the market during the depreciation or appreciation period. **Data:** The study sample consists of daily observations of bilateral exchange rates against the US dollar for the countries of the Black Sea region (Russia, Romania, Ukraine, Turkey, Georgia, and Bulgaria); the total number of observations reached 7842, with 1307 views for each country during the period from 1st of Jan 2015 to the 26th of Feb 2020. **Method/Tools:** we employ the Regular Vine copula approach, which is multivariate copula functions; this approach deal with dependency between variables by using tail dependence coefficients to assess the interdependency of both positive and negative extreme cases. **Findings:** The results of the study indicate the existence of a strong geographical pattern of currency dependency between Black Sea countries as follow: First, The Russian Ruble affect all the countries of the Black Sea region in the of appreciation and depreciation periods except on Turkey, just in depreciation periods, there's no dependency in appreciation periods between Turkey and Russia. Second, the Turkish Lira effects on both Ukrainian Hryvnia and Bulgarian Leva in appreciation and depreciation periods. Third, Bulgarian Leva affects Ukrainian Hryvnia in appreciation and depreciation periods, and finally, Georgian Lari affects only Ukrainian Hryvnia in depreciation periods. **Contributions:** This study is considered the first study that discusses regional contagion in Black Sea countries, providing insight into how the exchange rate in one of these countries reacts to exchange rate crises in the others.

Keywords: Exchange rate, black sea countries, dependency, regular vine copula.
JEL Classification: F31, G01, C58

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1. Introduction

The need for a trusted estimator for investment optimization makes the exchange rate one of the crucial financial applications in international investing, where the exchange rate fluctuations impact the anticipated profitability and risk of financial assets. Traders, international companies, and policymakers need foreign policy evaluations and integration of international economic policy to make appropriate plans to control international investments (Cubillos-Rocha *et al.*, 2019). It is key to the risk-avoidance actions of investors holding positions in global capital systems, as well as to foreign policy evaluation and global economic policy planning (Loaiza-Maya *et al.*, 2015b). Thus, studying exchange rate correlation is considered one of the significant subjects of interest in terms of financial exposure.

Many studies have been conducted across different countries and periods about the exchange rate between nations. These studies have shown that the correlation between exchange rates in turmoil and financial crises differs significantly across time. For instance, Loaiza-Maya *et al.* (2015a) showed that the exchange rate contagion during a financial crisis has a greater correlation than other times. This significant correlation in financial crisis highlights the importance of studying exchange rate contagion across the world and its effects, especially when recalling the Asian financial crisis (1997), which had a geographical pattern, as well as the mortgage crisis in the United States, which caused a spillover effect around the world, and other separate crises that struck Argentina, Russia, Turkey, and others.

Many definitions and classifications for financial contagion have been introduced in the literature. Empirical studies have adopted various definitions of contagion based on their purpose. The present study follows Dornbusch *et al.*'s (1999) definition for dependency, which indicates the transfer and spillover of financial shocks, mostly negative shocks, from one market to another between countries. This phenomenon has been observed through co-movements of financial assets and exchanges rate in different markets with strong market interdependence.

Currency crises affect countries in geographic proximity. Several studies have investigated the existence of regional contagion across the world; Glick and Rose (1999) provided support empirically for how currency crises tend to be regional. They showed that the currency crisis tends to be regional and that international trading plays a crucial role in currency crisis spillover between regional countries. Tskhadadze (2019) tested the regional financial contagion between Russia and the soviet union and Turkey. Tskhadadze's (2019) findings supported the results of Glick and Rose (1999) and showed that trade openness played a crucial role in spreading the financial contagion. Loaiza-Maya *et al.* (2015b) investigated the existence of financial contagion in Latin American countries. The study found that the dependence between countries is significant periods of appreciation, whereas they found no evidence of financial contagion in periods of depreciation. Finally, a recent study was conducted by Cubillos-Rocha *et al.* (2019), which showed that exchange rate contagion takes place within countries in the same region. In this context, this study examines currency dependency in the form of a geographical pattern in the Black Sea countries; more precisely, we investigate whether exchange rate shocks on one of the Black Sea countries affect the neighbouring countries' currencies.

The Black Sea region comprises six countries: Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine. Two leading countries of these six, Russia and Turkey, have recently faced crucial financial shocks to their exchange rates during the study period, 2015-2020. For example, the Russian crisis, which began in the second half of 2014 and its effects appeared on the Russian economy since the beginning of 2015, which caused the decline of the Russian ruble (Hartley, 2015), and the Turkish crisis that began in 2018 and caused high inflation and a depreciation of the Turkish currency (Goujon, 2018).

Since there are a limited number of studies that tested regional contagion, this study is considered an addition to the literature concerned about regional contagion. Also, this study is considered the first study that discusses regional contagion in Black Sea countries which provides an insight into how the exchange rate in one of these countries reacts to exchange rate crises in the others.

Different tools were employed in the literature to test regional exchange rate dependency. In this study, we employ the Regular Vine copula approach, which is multivariate copula functions; this approach can overcome the cons of regular correlation and deal with dependency between variables by using tail dependence coefficients to assess the interdependency of both positive and negative extreme cases (Loaiza-Maya *et al.*, 2015a). Regular Vine copula is considered one of the most recent trusted and development types of the Copula; it allows for very flexible dependency and can measure linear and nonlinear correlation. We model Multivariate Copula between the variables by following Dissmann *et al.* (2013); the marginal distribution is modelled using GARCH (1,1) with t student innovation.

The study measures the cross-market dependency by looking for significant dependency in the tails; any significant dependency reflects the co-movement in the market during the depreciation or appreciation period. Our main finding shows that the exchange rate movement during the appreciation (depreciation) of the Russian exchange rate with other countries' exchange rates is faster than at normal times. For this, the opportunity for traders to diversify by investing in these pairs that include Russia is riskier, especially between Russia and Georgia (RUB_GEL), which have 78% tail dependence. Some cases, like Turkey and Georgia (TRY_GEL) and Romania with Georgia (RON_GEL), are independent of each other. The other pairs, which have a lower tail coefficient, have no risk of diversification using these currencies. This finding of the strongest dependency during the appreciation period is consistent with Cubillos-Rocha *et al.* (2019), Dimitriou *et al.* (2017), Dimitriou and Kenourgios (2013) and Loaiza-Maya *et al.* (2015b). The strongest dependence between Russia and other countries is in line with Tskhadadze (2019) finding that the Russian crisis spread geographically into neighboring countries like Ukraine, Turkey, Georgia, and other Soviet Union countries.

This paper is structured as follows: the literature review and previous studies are included in Section 2. Sections 3 demonstrate the methodology used in the study. Section 4 describes the data and discusses the result. Our conclusion is in Section 4.

2. Methodology

2.1 Model for The Marginal Distributions

As financial data are heavily reliant on past values and have many features that linear models cannot capture, GARCH (1,1) is employed as it is effective at capturing such volatility (Brooks, 2019), copula-based models have to consider this by employing the GARCH model. (for more see: Liu, 2011) Considering the dependency of financial markets is key to trading options and predicting market returns, Copula has employed in this field for a long time. However, the absence of tail dependence with Copula was credited to the global financial crisis in 2008 (Czado, 2019). This study utilizes semi-parametric IFM by considering two-step estimation. First, the standardized residuals are determined by using the conditional variance GARCH (1,1) model for the marginal distributions and then define copula data based on the standardized residual of GARCH. The first step involves the GARCH (1,1) modeling. It is known that the original assumption GARCH builds based on the normality of the disturbance term, which does not go with financial data that have fat tails. Typically, Student's t-distribution is employed in this field as follows:

$$Y_t = \sigma_t Z_t \tag{1}$$

$$\sigma_t = \omega + \alpha {Y^2}_{t-1} + \beta {\sigma^2}_{t-1} \tag{2}$$

where $\sigma_t = var(Y_t|Y_1, \dots, Y_{t-1})$ and the innovation Z_t is assumed to follow student t-distribution. The second step is to define the copula data based on the standardized residual obtained from the previous GARCH (1,1) model. This step generates pseudo observations that will subsequently be used in estimating the Copula. The following equation performs the generation of pseudo observation:

$$u_{it} = F(\frac{y_{it}}{\hat{\sigma}_{it}}; \hat{v}_i) \tag{3}$$

where $\hat{\sigma}_{it}^2$ is estimated conditional variance for market i= 1,2,..,6, $\hat{v}_i$ is degree of freedom, and t refers to time 1,2,…,T.

2.2 Copula

The concept of copulas refers to a particular joint distribution produced by a given marginal, and it can be constructed based on the following (Sklar, 1959) theorem: let $X = (X_1, \dots, X_n)$ a n-dimensional random vector with F, which is a univariate marginal continuous distribution function $F_1, \dots F_n$ on the interval [0,1], The joint distribution function can then be represented as:

$$F(X_1, \dots, X_d) = C(F_1(X_1), \dots, F_n(X_n)) \tag{4}$$

2.3 The Pair Copula Decompositions and Constructions (PCCs)

Conditioning is the best method for building multivariate distributions using only bivariate structures to achieving such a building was offered by (Joe, 1996) through constructing the first pair of copulas to create a multivariate copula in terms of distribution functions. Independently, Bedford and Cooke (2001, 2002) built new constructions of Copula represented in terms of density. In fact, they established a general structure for the definition of all potential constructions. The Pair-Copula Decomposition is given by $f(x_1, \dots, x_n)$; this density function can be factorized as:

$$f(x_n).f(x_{n-1}|x_n).f(x_1|x_2, \dots x_n) \tag{5}$$

Now, we can write the marginal distribution of the previous equation as follows:

$$f(x_i|k) = c_{x_i v_l|v-l}(f(x_i|k_{-l}), F(k_j|k_{-l})).f(x_i|k_{-l}) \tag{6}$$

where $f(x_i|k)$ is the bivariate density copula and the marginal density function product of x_i. $k = x_{i+1}, \dots, x_n$ and represent $x_i's$ marginal distribution, k_l is a variable of k set. The rest of the variable that remains in k after extracting k_l is denoted by k_{l-1}, i refers to {1,….,(n-1)} and the density function c is defined as:

$$\frac{\partial C(u_1, u_2)}{\partial u_1 \partial u_2} \tag{7}$$

Among several types of Pair Copula Decompositions and Constructions (PCCs), an interesting one is the regular vine copula, which calculates c as a product of bivariate Copula $\frac{n(n-1)}{2}$. This technique is helpful for modeling dependency as it allows for asymmetry and flexible upper and lower tail dependence (Loaiza-Maya *et al.*, 2015a). The description of the R-vine Copula introduced by Bedford and Cooke (2001, 2002) is as follows:

$$f(x) = \prod_{k=1}^{n} f_k(x_k) \prod_{i=1}^{n-1} \prod_{j=1}^{n-i} c_{(mi,i,mj,i|m_j+1,i,\dots,m_n,i)}\Big(F_{(mi,i|mj+1,i,\dots m_{n,i})}\Big)' \; F_{(mj,i|mj+1,i,\dots,m_{n,i})}\Big(x_{(mj,i|mj+1,i,\dots,m_{n,i})}\Big) \quad (8)$$

where the matrix element m matrix in R-vine is denoted by $m_{n,i}$. The tail dependence demonstrates how bivariate variables rely on each other in extreme cases. In other words, the tail dependence shows the possibility that a given variable exceeds a specific threshold, given that the other variable exceeds a specific threshold (Loaiza-Maya *et al.*, 2015a). The study follows Joe (1997) definition in estimating the upper and the lower dependence tails as follow:

$$\lambda_u = \lim_{u \to 1^-} p\big(X_1 > F_1^{-1}(u) \big| X_2 > F_2^{-1}(u)\big) = \lim_{u \to 1^{-1}} \frac{1 - 2u + C(u,u)}{1-u} \quad (9)$$

$$\lambda_m = \lim_{u \to 0^-} p\big(X_1 < F_1^{-1}(u) \big| X_2 > F_2^{-1}(u)\big) = \lim_{u \to 0^{+1}} \frac{1 - 2u + C(u,u)}{1-u} \quad (10)$$

3. Data and Result

This study is focused on testing the geographical pattern of tail dependence in the Black Sea region, which includes countries that have recently faced financial turmoil, such as Turkey and, Russia. The study uses the exchange rate for six countries located in this region for testing tail dependency in the Black Sea region, namely Bulgaria (BGN), Georgia (GEL), Romania (RON), Russia (RUB), Turkey (TRY), and Ukraine (UAH). Bulgaria and Romania are members of the European Union. The study period covers five years, and it extends from the 1st of Jan 2015 to the 26th of Feb 2020. The number of observations for each variable is 1307 after standardizing the market calendars by removing non-mutual observations that occurred during the holidays of other countries. The data is in the form of daily observations and obtained from investing websites. Figure 1 exhibits the exchange rate behaviour for the series. Bulgaria and Romania show appreciation around 2018 and depreciation after that. It is clear that Turkey experienced currency depreciation during the study period while Russia showed depreciation until around 2016 and appreciation after that. The financial data are considered as noisy data. Consequently, the data are converted to continuous daily returns by taking the first difference of the natural logarithms of the exchange rate. The bilateral exchange rate of domestic currency against the US dollar was employed for each country.

Table 1 and Table 2 show the descriptive statistics and Pearson correlation of the variables, respectively. The descriptive table shows that the Russian exchange rate fluctuated the most, as it has the most significant standard deviation of 4.9 with a range of 33.6, which reflects the volatility of the Russian exchange rate during the study period. The Bulgarian exchange rate is the most stable as its standard deviation is 0.06 with a mean of 1.7 and a range of 0.31. From the descriptive statistics table, it appears that is not all countries' exchange rates except Ukraine have evidence for the fat tail, which shows the risk of the opportunity of loss

occurring if the kurtosis excess 3 and a negative skew with -1.54. The kurtosis for Georgia and Romania is negative, with values -0.27 and -0.86, respectively. In Bulgaria, the mean equals the median, which is 1.74, and the skew is negative with a value of -0.4. It is clear that the currencies of Russia and Ukraine fluctuated the most according to the study variables as they have standard deviations of 4.95 and 2.30, respectively. They were followed by Turkey, which has a standard deviation of 1.23.

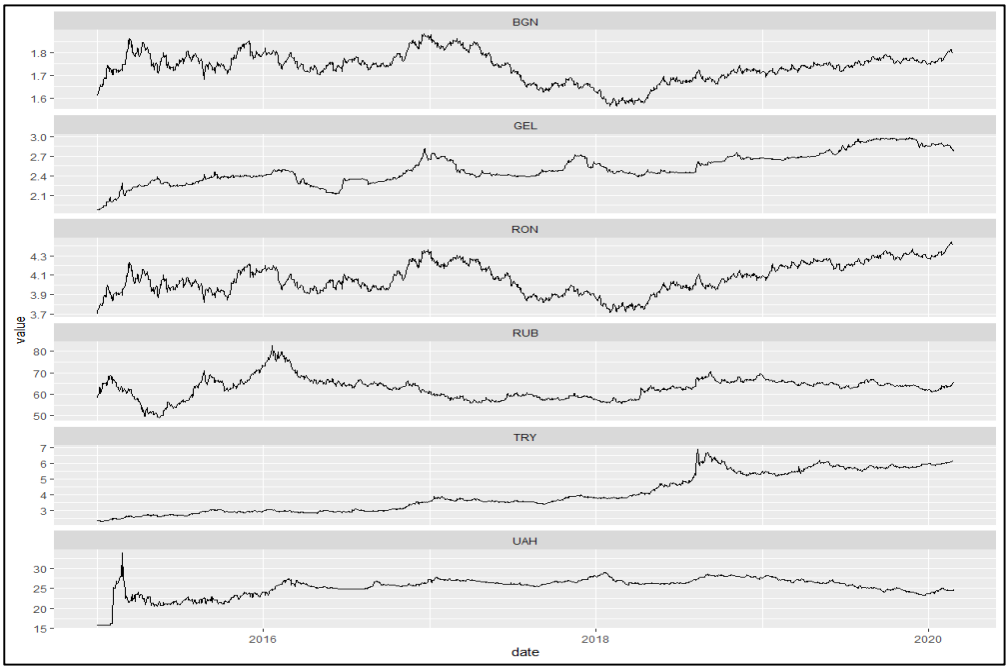

Figure 1: Bilateral exchange rate against the US dollar

Table 1: Descriptive statistics

	Mean	SD	Median	Min	Max	Range	Skew	Kurtosis
BGN	1.74	0.06	1.74	0.05	1.56	0.32	-0.40	0.01
GEL	2.51	0.23	2.46	0.23	1.88	1.10	0.22	-0.27
RON	4.07	0.16	4.06	0.18	3.70	0.74	0.04	-0.86
RUB	62.80	4.95	63.51	4.10	49.07	33.61	0.29	1.24
TRY	4.03	1.23	3.64	1.15	2.28	4.60	0.50	-1.26
UAH	25.37	2.30	26.02	1.57	15.80	17.95	-1.54	3.87

For preliminary testing of the dependency, the study evaluates the unconditional Pearson correlation between the study variable. Table 2 shows the Pearson's correlation coefficients between the exchange rate of the variables. It appears that the highest correlation coefficient is between Turkey and Georgia, with a correlation coefficient of 0.84, whereas between Bulgaria and Romania, the coefficient value is 0.77. Also, a high correlation coefficient can be observed between Romania and Georgia of 0.63. All correlation coefficients are positive except for negative correlations between the exchange rates of Turkey and Bulgaria exchange rate with a correlation coefficient of -0.13 and between Ukraine and Bulgaria with a correlation coefficient of -0.21. The weakest correlation coefficients are between Ukraine - Romania and Ukraine - Russia with values of 0.07 and 0.08, respectively.

Table 2: Pearson correlation

	BGN	GEL	RON	RUB	TRY	UAH
BGN		0.10	0.77	0.16	-0.13	-0.21
GEL	0.10		0.63	0.14	0.84	0.41
RON	0.77	0.63		0.21	0.48	0.07
RUB	0.16	0.14	0.21		0.19	0.08
TRY	-0.13	0.84	0.48	0.19		0.44
UAH	-0.21	0.41	0.07	0.08	0.44	

We can notice that most exchange rate pairs, regardless of correlation coefficient value, move together in the same direction. Since they have a positive correlation, while some of them, such as Turkey and Bulgaria exchange rate and Ukraine and Bulgaria exchange rate, have a negative correlation, they move in the opposite direction, and this means if one of them is an appreciation to USD, the second pair will be depreciation. Figure 2 exhibits the Pearson correlation between the variables.

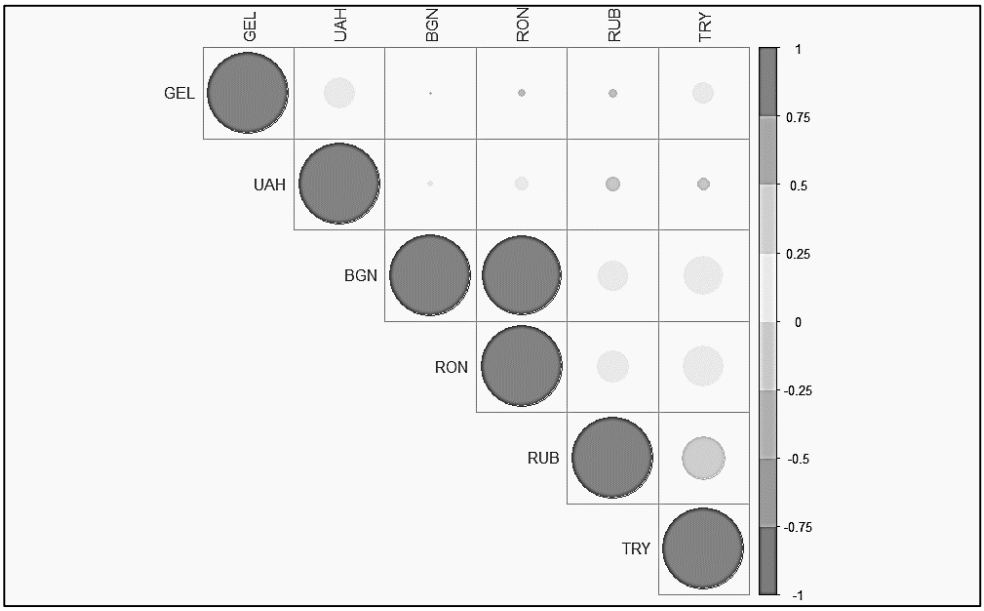

Figure 2: Pearson correlation between the variables.

It is important to note that there is a significant limitation of using unconditional correlations in that it can be challenging to determine whether the associations in regular times and in times of significant market fluctuations are different. Also, due to the high frequency of the observations, it is difficult to determine the effect size of these coefficients. Consequently, the copula approach is considered the best function to overcome this limitation by considering these limits (Cubillos-Rocha *et al*., 2019). Based on this, we construct multivariate Copula. We employ the Regular Vine copula, which has a feature that enables it to deal with dependency between variables by using the tails dependence coefficients to assess the dependency between exchange rates. For constructing the regular vine copula, we start by adopting GARCH (1,1) with t innovation to eliminate the serial correlation and allow for a dependence structure between the standardized residual of the variable (Czado, 2019). The multivariate specification test and univariate specification test for the standardised residual are shown in Table 3 and Table 4, respectively.

Table 3: Multivariate specification tests for the standardized residuals

Tests	Lags	Statistic	P-Value
Portmanteau*	100	3576.088	0.440
LM**	100	3621.559	0.855

Notes: * indicates null hypothesis: no autocorrelation and ** indicates null hypothesis: no multivariate GARCH effect.

Table 4: Univariate specification tests for the standardized residuals

Variable	ARCH (LM) (lag=100)	Portmanteau (lag=100)
BGN	0.9625	0.9129
GEL	0.1134	0.0353
RON	0.9660	0.9520
RUB	0.8403	0.5313
TRY	0.3540	0.2705
UAH	0.1057	0.2680

Notes: Null hypothesis: No arch effect.

The procedures of Dissmann *et al.* (2013) were followed in constructing the vine copula for the pair of exchange rates by employing the algorithm suggested by Prim (1957) to maximize the sum of absolute empirical Kendall correlation coefficients to choose the tree structure then select the copula family for each pair using the "goodness of fit test" via minimizing AIC. Then, the ML method is used to estimate the parameter. Figure 3 shows the plot of regular Vine copula trees and its estimated parameters are reported in Table 5.

There is a vast family of Copula that can be employed. For exchange rate pairs, the copula family has been chosen based on goodness fit test among 39 types of Copula, namely (Gaussian, Student t, Clayton, Survival Clayton, Rotated Clayton (90 degrees), Rotated Clayton (270 degrees), Gumbel, Survival Gumbel, Rotated Gumbel (90 degrees), Rotated Gumbel (270 degrees), Frank, Joe, Survival Joe, Rotated Joe (90 degrees), Rotated Joe (270 degrees), Clayton-Gumbel, Survival Clayton-Gumbel, Rotated Clayton-Gumbel (90 degrees), Rotated Clayton-Gumbel (270 degrees), Joe-Gumbel, Survival Joe-Gumbel, Rotated Joe-Gumbel (90 degrees), Rotated Joe-Gumbel (270 degrees), Joe-Clayton, Survival Joe-Clayton, Rotated Joe-Clayton (90 degrees), Rotated Joe-Clayton (270 degrees), Joe-Frank, Survival Joe-Frank, Rotated Joe-Frank (90 degrees), Rotated Joe-Frank (270 degrees), Tawn type 1, Survival Tawn type 1, Rotated Tawn type 1 (90 degrees), Rotated Tawn type 1 (270 degrees), Tawn type 2, Survival Tawn type 2, Rotated Tawn type 2 (90 degrees) and Rotated Tawn type 2 (270 degrees).

Table 5: Regular vine specification

Pairs	Copula family	Par1	Par2
RUB_UAH	Student t	0.1221	2.0001
RUB_BGN	Student t	-0.0232	2.6904
RUB_GEL	Student t	0.9589	3.1758
RUB_RON	Student t	0.4151	6.1243
RUB_TRY	Gumbel	1.5417	0.0000
TRY_UAH	Student t	0.0024	4.9907
TRY_BGN	Student t	0.0486	11.4020
TRY_GEL	Independence copula	0.0000	0.0000
TRY_RON	Frank	0.7161	0.0000
RON_UAH	Rotated Joe copula (270 degrees)	-1.0359	0.0000
RON_BGN	Rotated Tawn type 2 (270 degree)	-1.1181	0.0940
RON_GEL	Independence copula	0.0000	0.0000
GEL_UAH	Clayton	0.0646	0.0000
GEL_BGN	Rotated Joe copula (90 degrees)	-1.0339	0.0000
BGN_UAH	Student t	-0.0068	12.0718

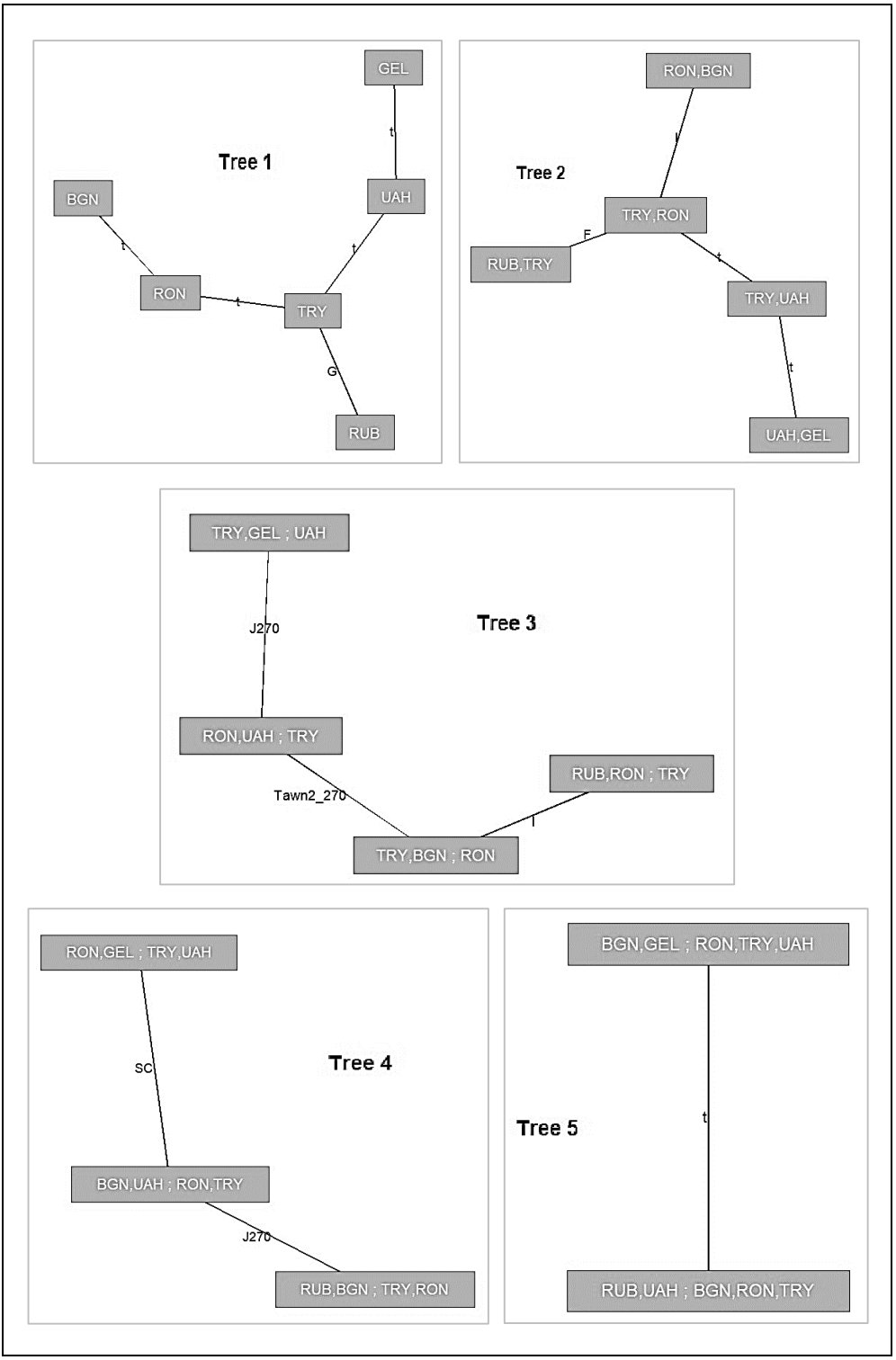

Figure 3: The plot of regular Vine copula trees

From Table 5. we can see that each pair of Romania with Georgia (RON_GEL) and Turkey with Georgia (TRY_GEL) are independent, which means that the Romanian leu and Georgian lari are independent of each other, and the same applies to the second pair (Turkish Lira and Georgian lari).

Table 6 shows the upper and lower tail dependence coefficients of the bivariate exchange rate pairs. The coefficient of the tails indicates how the pairs are asymptotically dependent on their tails (upper or lower or both tails) and the strength of this dependence between them. The upper tail coefficients are linked with exchange rate movements through extreme depreciation. The table shows that Russia has the strongest tail dependence with other countries, followed by Turkey, which has a tails dependence with Ukraine, while the others have a negligible tails coefficient. The strongest upper tail dependence is between Russia and Georgia (RUB_GEL), with a tail dependence coefficient of 78%. This indicates that currencies co-move considerably faster than in usual times across cycles of intense currency appreciation with regard to the US dollar. A strong upper tail follows this between Russia and Turkey (RUB_TRY) with a 43% tail dependence coefficient. For RUB_UAH, RUB_BGN, RUB_RON and TRY_UAH, the upper tail dependence coefficients are 22%, 12.6%, 12.9% and 5%, respectively. The rest of the pairs have either small coefficients or independence.

Table 6: Tail dependence coefficient

Pairs	Upper tail	Lower tail
RUB_UAH	0.223021200	0.223021186
RUB_BGN	0.126614647	0.126614647
RUB_GEL	0.781254000	0.781254000
RUB_RON	0.129112700	0.129112700
RUB_TRY	0.432326100	0.000000000
TRY_UAH	0.050411240	0.050411241
TRY_BGN	0.005495005	0.005495005
TRY_GEL	0.000000000	0.000000000
TRY_RON	0.000000000	0.000000000
RON_UAH	0.000000000	0.000000000
RON_BGN	0.000000000	0.000000000
RON_GEL	0.000000000	0.000000000
GEL_UAH	0.000022000	0.000000000
GEL_BGN	0.000000000	0.000000000
BGN_UAH	0.002967000	0.002967386

Notes: The dependency in tails ranges between zero and one, zero indicates no dependency, one indicates 100% dependency.

The coefficient of the lower tails dependence is linked to exchange rate movement during the appreciations of the exchange rate of the pairs of the exchange rate. The lower tail dependence coefficient has almost the same result as the upper tail coefficient except for Russia and Turkey, which has no dependence on the lower tail, thus indicating no correlation between the Russian ruble and Turkish Lira during the period of appreciation. These results are consistent with those of Cubillos-Rocha *et al.* (2019), Dimitriou *et al.* (2017), Dimitriou and Kenourgios (2013), Eduardo *et al.* (2013) and Loaiza-Maya *et al.* (2015b).

The pairs TRY_GEL, TRY_RON, RON_UAH, RON_BGN, RON_GEL, and GEL_BGN, have no dependency in appreciation and depreciation periods since the lower and upper tails have a zero value. The increase in international capital flows and trade liberalization worldwide has led to significant co-movement between exchange rates. Russia is considered the main oil and gas producer in the Black Sea area, making Russia a prominent partner for this region. The result indicates that the exchange rate movement during periods of appreciation (depreciation) of the Russian exchange rate with other countries' currencies is

faster than at regular times. Consequently, the opportunity for traders to diversify by investing in these pairs that include Russia is riskier, especially the pair of Russia and Georgia (RUB_GEL) that has a tail dependence of 78%. In some cases, like Turkey and Georgia (TRY_GEL) and Romania with Georgia (RON_GEL), which are independent with no risk, and other pairs with lower tail coefficients, there is no risk of diversification these currencies. The strongest dependence between Russia and other countries is in line with Tskhadadze (2019) findings who found that the Russian crisis spread geographically into neighboring countries such as Ukraine, Turkey, Georgia, and other former Soviet Union countries.

4. Conclusion

This study investigates the existence of a geographical pattern of dependency in exchange rates among Black Sea countries (Russia, Romania, Ukraine, Turkey, Georgia, and Bulgaria) by constructing a multivariate copula by using regular vine copula and GARCH (1,1) with t-innovation during the period from the 1st of Jan 2015 to 26th of Feb 2020. The data used were in the form of continuous daily returns. The bilateral exchange rate of the domestic currency against the US dollar was employed for each country.

The results reveal the existence of a strong geographical pattern of dependency between Russia and other countries. The upper tail shows that Russia has the strongest tail dependence with other countries, followed by Turkey, which has a tails dependence with Ukraine, while the others have negligible tails coefficients. The strongest upper tail dependence is between Russia and Georgia (RUB_GEL), with a tail dependence coefficient of 78%. This indicates that currencies co-move considerably faster than in usual times across cycles of intense currency appreciation with regard to the US dollar. A strong upper tail follows this between Russia and Turkey (RUB_TRY) with a tail dependence coefficient of 43%. The lower tail dependence coefficient has almost the same result as the upper tail coefficient, apart from the fact that Russia and Turkey have no dependence in the lower tail, which means that there is a correlation between the Russian ruble and the Turkish Lira during the appreciation time. These results are consistent with Cubillos-Rocha *et al.* (2019), Dimitriou *et al.* (2017), Dimitriou and Kenourgios (2013), Loaiza-Maya *et al.* (2015b). The strongest dependence between Russia and other countries in line with Tskhadadze (2019) findings who found that the Russian crisis spread geographically into neighboring countries as Ukraine, Turkey, Georgia, and other former Soviet Union countries. Generally, the results indicate that the exchange rate movement during the appreciations (depreciation) of the Russian exchange rate with other countries' exchange rates is faster than normal time. Consequently, the opportunity for traders to diversify by investing in these pairs that include Russia is riskier.

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