

MASTER THESIS

Title: Analysis of exchange rate and stock market developments from 2020 onwards

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Master thesis

Master in Actuarial and Financial Sciences

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ABSTRACT

Since 2020, the world has witnessed several major events, which had profound impacts on the exchange rate and the stock markets related to the US, China, the EU, and Russia. This thesis first demonstrates the linkage between the exchange rates and stock prices through relevant literature review. Then it conducts data analyses and comparisons, among the returns of the exchange rates and stock markets, and among the returns of the US stock market and other stock markets expressed in USD, to confirm the existence of correlations and Granger causality in some economic entities during specific times and provide advice on oversea investment for investors.

Keywords: exchange rate, stock market, rate of return, major events.

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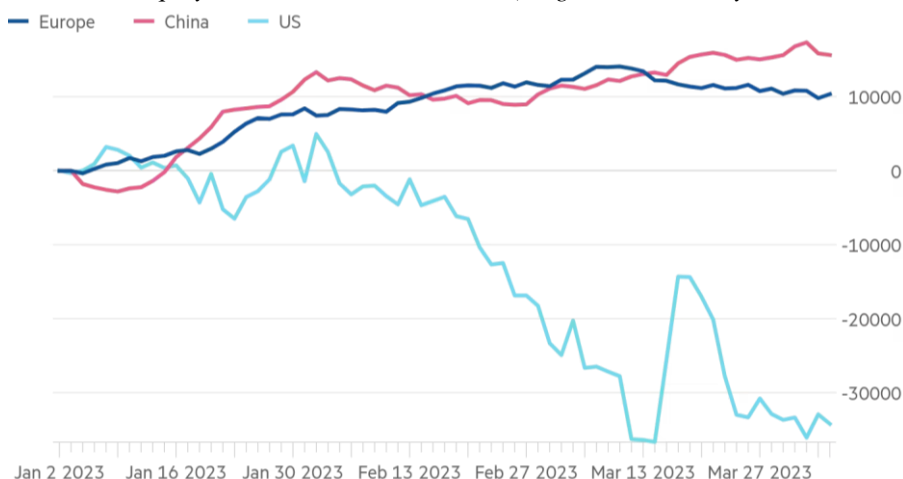
1 INTRODUCTION

1.1 Introduction

According to financial flows data provider EPFR, so far this year, investors have withdrawn \$34 billion from US equity funds, almost \$16 billion has flowed into Chinese equity funds, and \$10 billion into European equity funds, as can be seen in Figure 1 below.

Figure 1

Cumulative Equity Fund Flows, \$million, YTD (Megaw, N., & Darbyshire, M., 2023)



Source: EPFR
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As pointed out above, US fund managers are increasing investments in international stock markets, hence the need for an analysis of the developments of the stock markets in some of the most important economic entities around the world other than the United States, as well as the exchange rates of USD against other currencies since it's an important factor involved in overseas investments. This thesis chooses the period from 2020 onwards, trying to provide up-to-date and sufficient information for investors from the US or other countries especially when facing the occurrence of major events.

1.2 Background of Study

Since the beginning of 2020, the world has experienced a series of major events that have had far-reaching consequences for the world economy. After two years of ongoing trade friction between China and the US, the two parties finally signed the “phase one” trade deal on January 15, 2020, but most tariffs still remain in place, and the market uncertainties and risks were still high. Stock markets around the world then suffered major losses because of the outbreak of the COVID-19 pandemic. Lockdown measures and restrictions implemented to contain the spread of the virus have had profound impacts on consumer demand, employment, and economic contractions in many economic entities. In 2020, global GDP fell by 3.1% compared to 2019, which is more than 6% lower than forecasted at the beginning of that year, leading to the worst recession in the world economy since the Great Depression of 1929. What is more, the Russia-Ukraine conflict has further heightened geopolitical tensions and weakened global economic growth, with

implications for markets, global trade, and investment, pushing up global inflation. In the face of rising inflation, central banks of many economic entities, led by the Federal Reserve, have rapidly and sharply tightened monetary policy and hiked interest rates, again significantly dragging down economic growth.

Those events discussed above have sparked significant fluctuations in stock markets, particularly in the US, China, European Union, and Russia, and the exchange rate of USD against the currencies of the other three economic entities, which all are key players in the world. The US not only has the largest consumer market in the world but also has the world's largest stock exchange. What is more, the USD is universally used as international trade and reserve currency. China, on the other hand, is becoming an increasingly important participant in the global supply chain and international trade because of its large market size, manufacturing base, and rapidly growing consumer spending. With twenty-eight member countries, the EU is of the utmost importance to the world, being a political and economic union with a sizable and developed economy. According to the data provided in the World Economic Outlook (International Monetary Fund, 2023), the GDP of the US, China, and the EU ranks in the top three of all the economic entities, counting for around 61% of the overall GDP of the world. The same resource also claims that Russia has reentered the top ten economies in the world in 2022 for the first time since 2014, despite a series of sanctions against it during that year. Russia has always played a vital role in international energy cooperation and geopolitics. Additionally, Russia is a country with a large market potential and consumer demand. Therefore, this thesis will first focus on the stock markets in these four economic entities and the exchange rate of USD against the currencies of the other three economic entities. After that, this thesis will take a closer look at the returns of the US stock market and other stock markets considering the exchange rates.

1.3 Research Aims and Objectives

This thesis aims to first study the linkage between the exchange rates and stock markets through literature review. Then analyze data of the stock markets in China, the EU, and Russia and the exchange rates of USD against their currencies since 2020, with a particular focus on the impact of the major events. Understanding the linkage between the stock markets and the exchange rate of the USD against their currencies, in other words, the US foreign exchange market towards them, is crucial for investors, as it can inform them when it comes to the decision-making processes related to overseas investment and risk management. By examining the influence of these major events on the stock markets and exchange rates, this study also seeks to clarify the effect of major events on stock markets and exchange rates. These comprehensive analyses will serve as the background for this thesis, setting the stage for a deeper exploration at the end of the returns of the US stock market and other stock markets expressed in USD from 2020 onwards considering investment returns.

1.4 Structure of The Thesis

The remaining part of this thesis has been organized in the following way: Section 2 reviews the previous research about the linkage between exchange rates and stock prices,

the impact of major events on these two variables, as well as the relationships among the US, China, the EU, and Russia in the global economy, to better understand the internal connecting link among these economic entities when a major event occur. Section 3 focuses on introducing the selected data, including the data sources, and preprocessing, in which logarithm and log-difference of original data have been assessed the stationarity and used to calculate the rate of returns, followed by the analysis of general descriptive statistics. Section 4 analyzes the empirical results from correlation analysis and Granger Causality test. In the end, it will demonstrate the time series plots of the returns of the stock markets in the four economic entities, all expressed in USD, and compares this combined stock market returns with the former ones. Finally, Section 5 concludes this thesis, by summarizing the main findings from the previous analyses and comparisons.

2 REVIEWS OF THE EMPIRICAL LITERATURE

2.1 The Linkage Between Exchange Rates and Stock Prices

Many researches, if not focusing on one major event, compare the difference in the short term and in the long term. On top of that, previous studies explore the correlation and Granger causality between the exchange rates and stock prices. For example, Ajayi and Mougoue (1996) used an error correction model to explore the linkage between stock indices and exchange rates in eight advanced economies and discovered that, an increase in the overall domestic stock price has a short-term negative impact on the value of the domestic currency, however, in the long term, the impact is positive. What is more, the stock market is negatively impacted both in the short term and long term by currency depreciation. Nieh and Lee (2001) analyzed the dynamic relationship between stock prices and exchange rates in G-7 countries and found no meaningful long-run relationship, but the short-run significant relationship was found for one day in some G-7 countries.

Many researchers have studied the Asian markets, for instance, Abdalla and Murinde (1997) used monthly data to study four Asian countries and obtained that the exchange rates are the cause of the stock prices in three countries other than Philippines. Lean et al. (2011) explored the relationship between the two variables in eight Asian markets and confirmed no cointegration relation. Besides, there is a weak long-term unidirectional Granger causality from exchange rates to stock prices throughout the time of observation in Korea. What is more, they found that the short-term intertemporal co-movements between the two variables show that they predominantly influence each other contemporaneously. Tsai (2012) used a quantile regression model to study six Asian markets and found the two variables negatively related. This relation is more apparent when exchange rates are extremely high or low.

With further development of econometric models, more methods using different models, such as the GARCH family models, have been gradually applied to study the correlation between stock and foreign exchange markets.

2.2 The Impact of Major Events on Exchange Rates and Stock Markets

Speaking of major events, it is of interest to study the ones that affect the currencies and stock markets. Several studies have focus on the Asian financial crisis in 1997, which affected much of East Asia in the currencies and stock markets. Granger et al. (2000) studied nine Asian markets during the period of the Asian financial crisis and found no correlation between the stock markets and exchange rate markets in Indonesia and Japan. In Korea, the stock price led the exchange rate, whereas in the remaining markets, the reverse applies. Phylaktis and Ravazzolo (2005) found that the stock markets and foreign exchange markets are positively related, with the US stock market acting as a conduit for these links that are not affected by restrictions on foreign exchange. In addition, their research demonstrates that the financial crisis had a fleeting effect on the long term co-movement of the two markets by using recursive estimating. Pan et al. (2007) explored seven East Asian markets and found no significant causality from the stock prices to exchange rates in any market during the Asian financial crisis. Tsagkanos and Siriopoulos (2013) studied the sample of the four years after the financial crisis of 2007-2008,

adopting a more advanced econometric model, and found that in the short run, there is only a causality between the two in the US, while in the long run, there is a causality in the EU.

Since the COVID-19 pandemic started in 2020, its impact has already been studied by many. Considering that this thesis takes various economic entities into account, previous studies that focused on only one economic entity will not be demonstrated. Bissoondoyal-bheenick et al. (2020) studied the impact of the COVID-19 pandemic on stock index returns and volatility connectedness using the approach of F.X. Diebold and Yilmaz for the G20, which includes the US, China, the EU, and Russia. They found that during the pandemic era, there was an increase in both stock return and volatility connectedness, which is more prominent as the pandemic's severity increases. Many have confirmed the correlations and risk spillover effect among different stock markets during the COVID-19 pandemic era. For instance, Huang et al. (2022) built an ARMA-GARCH model to investigate the impact of COVID-19 pandemic on China, the US, and other countries and how the stock index returns of the five countries have been impacted by one another. They suggest that when a major event occurs, the stock market will be erratic, those with high tolerance for risk can buy low and sell high. But for those who are risk-averse, it is better to invest in the stock market when the major event has come to an end.

In terms of the impact of the COVID-19 pandemic on the linkage between the stock price and exchange rate, Rai and Garg (2022) used volatility modelling and found that, in the majority of the BRIICS economies, between stock and exchange returns, there are significant negative dynamic correlations and volatility spillovers. Additionally, the bond was stronger during the early lockdown days. Their research shows that, during the COVID-19 pandemic, there were significant risk transfers between the two markets, which caused a decrease in the domestic stock returns and subsequent capital outflows, boosting exchange rates.

2.3 The Relationship Among The US, China, The EU, And Russia

Studying the third party's strategic choice under the US-China competition helps to understand the influence a major event can have on the markets of every involved economic entity. Cao (2021) applied a VAR model using impulse response functions and forecast error variance decomposition and found that the EU's relationship with China is likely to improve as the US steps up its efforts to contain its relationship with China, while tensions between Russia and China over its policy towards China may increase. The US's strengthening of ties with the EU will lead to the EU's strategy of isolation from China, whereas the US's policy towards Russia has no impact on the Russian policy towards China. As a result, should US-China's strategic competition continue to heat up, the relationship between China and Russia may be worse, China may even find itself in a position where Russia is seen as a threat. Whereas the EU might end up providing China with a crucial channel for easing external strategic pressure.

2.4 Summary

Previous studies provide an idea of the linkage between the exchange rates and stock prices, it has been confirmed that there may or may not exist correlations and Granger causality according to different periods of time, in the long term or short term and the selected markets, thus the results could vary a lot. Therefore, these studies lay a groundwork for up-to-date research into the exchange rates and stock markets in the US, China, the EU, and Russia from 2020 onwards.

Furthermore, when a major event occurs, the stock market will be erratic, it is important to consider the degree of involvement and the type of influence received of the country to invest in. An entry point is where did this major event start from and how is the relationship between the country in the center of this major event and the one to invest in.

In the following sections, correlations analysis and Granger causality test will be applied to the selected sample data, conclusions about investments under the influence of a major event and relationship among the four countries will be considered.

3 DATA SELECTION AND FUNDAMENTAL ANALYSIS

3.1 Data Selection

Although this thesis intends to study the period from 2020 onwards, trying to focus on figuring out the impact due to the outbreak of the COVID-19 pandemic and the Russia-Ukraine conflict, it's of vital importance to include a period of time before these two major events happened as a comparison. For this reason, this thesis, in fact, selects the daily data on the representative stock indices and exchange rates of China, the EU, and Russia for the period from January 1, 2018, to April 1, 2023. Only valid data with consistent trading days in both the stock market in each economic entity and the US foreign exchange rate market towards them are retained. At the end of Section 4, the stock index of the US will also be added as a comparison to study the returns in all four stock markets. This thesis chooses daily data for each sample economic entity as it provides more accurate results that can better capture the linkage between the exchange rates and stock indices. Since the sample includes data of both before and after the outbreak of the COVID-19 pandemic and the Russia-Ukraine conflict, the analyses are broken down by the dates. The time intervals and the amount of data included are shown in Table 1 below.

Table 1 <i>Time Interval and Amount of Data</i>			
Economic Entity	Period	Time Interval	Amount of Data
<i>US</i>	<i>Pre-COVID</i>	<i>01/01/2018 - 12/31/2019</i>	<i>502</i>
	<i>Pandemic Era</i>	<i>01/01/2020 - 23/02/2022</i>	<i>540</i>
	<i>Russia-Ukraine conflict</i>	<i>24/02/2022 - 01/04/2023</i>	<i>276</i>
<i>China</i>	<i>Pre-COVID</i>	<i>01/01/2018 - 12/31/2019</i>	<i>483</i>
	<i>Pandemic Era</i>	<i>01/01/2020 - 23/02/2022</i>	<i>518</i>
	<i>Russia-Ukraine conflict</i>	<i>24/02/2022 - 01/04/2023</i>	<i>269</i>
<i>EU</i>	<i>Pre-COVID</i>	<i>01/01/2018 - 12/31/2019</i>	<i>497</i>
	<i>Pandemic Era</i>	<i>01/01/2020 - 23/02/2022</i>	<i>544</i>
	<i>Russia-Ukraine conflict</i>	<i>24/02/2022 - 01/04/2023</i>	<i>280</i>
<i>Russia</i>	<i>Pre-COVID</i>	<i>01/01/2018 - 12/31/2019</i>	<i>490</i>
	<i>Pandemic Era</i>	<i>01/01/2020 - 23/02/2022</i>	<i>540</i>

	<i>Russia-Ukraine conflict</i>	<i>24/02/2022 - 01/04/2023</i>	258
Source: own elaboration			

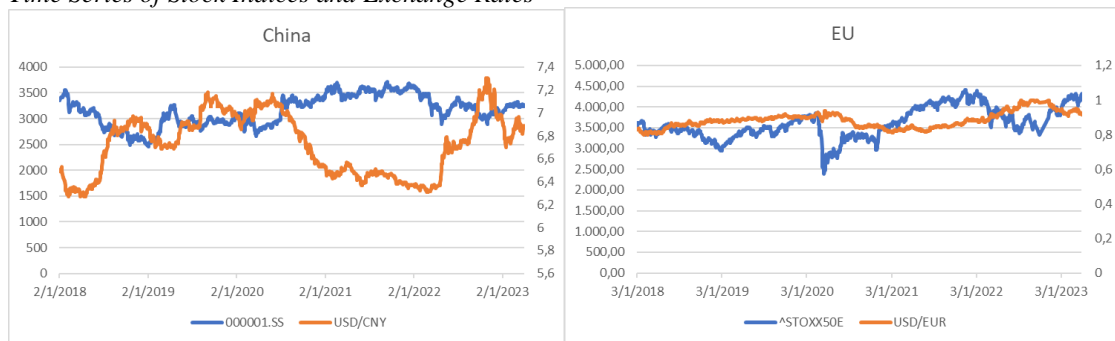
The primary focus of this thesis is on the most representative stock market indices and the exchange rate of the USD against other currencies of the selected economic entities. The included stock market indices are as followed: the Shanghai Composite Index (symbol: 000001.SS) represents the stock market in China, the Euro STOXX 50 Index (symbol: ^STOXX50E) represents the stock market in the European Union, and the MOEX Russia Index (symbol: IMOEX.ME) represents the stock market in Russia. The adjusted closing prices of the US dollar against the currencies of the sample economic entities, expressed using the direct quotation method, are chosen as the exchange rate indicators. The US dollar exchange rates against the currencies of these economic entities to be examined are the Chinese yuan (USD/CNY), the euro (USD/EUR), and the Russian ruble (USD/RUB). The US dollar-centric direct quotation method is selected because most of the international trade and capital flows involving the sample economic entities are denominated in US dollars.

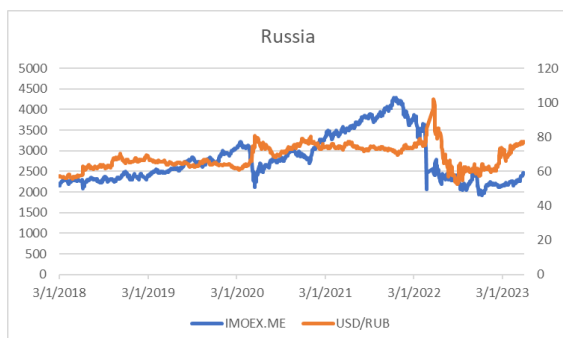
By examining these stock indices and exchange rate data, this thesis aims to first shed light on the performance of the stock markets and US foreign exchange market during the period of interest, which has been marked by significant global challenges which are the COVID-19 pandemic and the Russia-Ukraine conflict.

3.2 Time Series of Stock Indices and Exchange Rates

This thesis uses data from all times to plot the time series, as can be seen in Figure 2 below, in which the blue lines stand for stock indices while the orange line stands for exchange rates.

Figure 2
Time Series of Stock Indices and Exchange Rates





Source: own elaboration

Regarding the period from January 1, 2018, to December 31, 2021, which is added as a comparison, the first thing to be noticed is that significant fluctuations can be seen in the stock markets in China and the EU and the USD against CNY. In fact, all big European and Asian stock markets suffered similar losses in 2018 because so many events happened during that period, among which the still ongoing US-China trade war that started at the beginning of 2018 probably is the most influential one.

The US-China trade war, also known as the tariff war, was launched by Donald Trump, the former president of the United States, who imposed a barrage of tariffs in March 2018 after charging China with unfair trade practices and innovation theft, sparking a wave of trade fights around the world. The bad effect of the tariff rises not only affected the sectors that were subject to it hard, but it also spread to all other sectors, significantly negatively affecting the Chinese stock market.

Because of the US-China trade war, the devaluation of CNY began in March 2018. In November 2018, the exchange rate of USD/CNY reached its highest point after CNY's sharp decline of 11%, which was the result of the agreement between the two countries to stop imposing new tariffs on each other and enter a 90-day truce on December 1, 2018. CNY briefly appreciated, but then experienced two rounds of rapid depreciation in May and August 2019, respectively due to the US imposing higher tariffs and tariffs on even more goods. In October and December 2019, the US postponed the tariff hike and the US-China trade war eased again, thus the exchange rate fell back after reaching a new high in recent years.

On the other hand, the economic recovery of the EU has slowed down since 2018, the European Central Bank reduced its economic growth prospect three times in 2018. But being a significant US trading partner and having tight economic and trade ties with China, the EU was further impacted by the US-China trade war. The US trade policy weakened the demand for German exports, not to say that Brexit was also going on, consequently the stock market in the EU was at its lowest point until 2019, with pressure coming from many different sources.

Now focusing on the period from 2020 onwards. The outbreak of the COVID-19 pandemic produced a sharp decline in the stock indices in the EU and Russia in March 2020, because on March 11, the World Health Organization (WHO) declared the outbreak a "global pandemic". The next day, stock markets in eleven countries, including the US, had a crash. On March 13, the panic spread to big markets in Asia-Pacific. However, since then, all stock markets around the world have increased by over 62% by the end of 2020. Although, when the pandemic spread throughout Europe again at the end of

October 2020, there was another noticeable decline in both the European and Russian stock markets.

As for China, focusing on the exchange rate of USD/CNY, the year 2020 can be divided into two phases. From late January to May 2020, the COVID-19 pandemic spread quickly throughout the world, triggering extreme risk aversion in the global financial markets and a liquidity shock for the USD. The U.S. dollar index rose sharply, and CNY depreciated following it. From June to early December 2020, global market risk sentiment improved, with the U.S. dollar index decreasing significantly and CNY continuing to appreciate under the influence of the Federal Reserve and other major global central banks' liquidity easing. China's post-epidemic economic recovery then was also significant, as can be seen in the long-lasting downward trend in the exchange rate of USD/CNY.

The Russian-Ukrainian conflict caused a decrease in all three stock indices and a significant depreciation in RUB and CNY because of a strong USD, the US dollar's attributes as a safe-haven currency during the Russia-Ukraine conflict were underlined. The Russian financial market, on the other hand, experienced serious chaos in early March 2022 under the impact of extensive sanctions, and the exchange rate of RUB depreciated by more than 50%. But after Russia implemented the new payment mechanism for natural gas in RUB on April 1, 2022, the exchange rate of RUB appreciated sharply.

Here it can be said that among these three economic entities, the stock index and exchange rate in Russia always respond to the two major events more noticeably than others. When a major event occurs, the stock index decreases while the exchange rate increases. The exchange rate in the EU has always been stable, which might be due to the fact that the EU is a relatively stable political entity, which has helped to support the euro's value. It is worth mentioning that the EU stock index has been pulled down by not only the Russia-Ukraine conflict but also the surging inflation and central banks tightening monetary policy, with the total drop in European stocks hitting 13% this year, the highest since 2018.

China didn't respond to the outbreak of the Russian-Ukrainian conflict as fast as other economic entities, but in April 2022, affected by the increased risk of global stagflation due to the Russia-Ukraine conflict and the domestic pandemic in China, as well as the divergence of monetary policy between the US and China, CNY began a new round of devaluation. The Fed rate hikes in 2022 can be seen from Table 2 below.

Table 2 <i>Fed Rate Hikes in 2022</i>		
Date	Target Rate	Change
<i>March 17, 2022</i>	<i>0.25 - 0.50</i>	<i>.25</i>
<i>May 5, 2022</i>	<i>0.75 - 1.00</i>	<i>.50</i>
<i>June 16, 2022</i>	<i>1.50 - 1.75</i>	<i>.75</i>

July 28, 2022	2.25 - 2.50	.75
September 22, 2022	3.00 - 3.25	.75
November 3, 2022	3.75 - 4.00	.75
December 15, 2022	4.25 - 4.50	.50
Source: BOC Research Institute		

The Federal Reserve raised interest rates and hinted further hikes, leading to a stronger dollar against most major currencies. The ongoing Russia-Ukraine conflict continues to contribute to a sharp slowdown in European economic activity, which in turn causes a further decline in external demand for Asian exports. Therefore, later in mid-August, according to the analysis report made by BOC Research Institute (2023), the continuous decline in export growth weakened the trade surplus's support for the exchange rate, as can be seen from Figure 3 below. Besides, the increased divergence in monetary policy between the US and China and a weaker-than-expected recovery in the Chinese economy made CNY start another round of rapid devaluation.

Figure 3

Change In the YOY Growth Rate Of China's Export Value, \$, % (BOC Research Institute, 2023)



Source: Wind, China Research Net

3.3 Stationarity Test

After analyzing the time series of the stock indices and exchange rates, this paper then uses RStudio to further analyze the data. To avoid a series of problems caused by too much volatility in the data, first of all, this thesis takes the logarithm of stock indices and exchange rates. ADF (Augmented Dickey-Fuller) unit root test is used to assess the stationarity of the returns of the stock indices and exchange rates. The logarithm of stock indices of the Pre-COVID, Pandemic Era and Russia-Ukraine conflict periods are respectively represented by lns_1 , lns_2 and lns_3 , while the logarithm of exchange rates of the aforementioned time intervals are represented by lne_1 , lne_2 and lne_3 . The stationarity test results are presented in Table 2 below.

Table 3 <i>Stationarity Test Results</i>				
Economic Entity	Variable	ADF Statistic	P-value	Conclusion
<i>China</i>	<i>lns₁</i>	-6.2183	< 0.01	<i>Stationary</i>
	<i>lns₂</i>	-2.3226	0.4418	<i>Non-stationary</i>
	<i>lns₃</i>	-2.9279	0.1851	<i>Non-stationary</i>
	<i>lne₁</i>	-6.9671	< 0.01	<i>Stationary</i>
	<i>lne₂</i>	-7.0963	< 0.01	<i>Stationary</i>
	<i>lne₃</i>	-7.0753	< 0.01	<i>Stationary</i>
<i>EU</i>	<i>lns₁</i>	-1.8522	0.6408	<i>Non-stationary</i>
	<i>lns₂</i>	-7.9341	< 0.01	<i>Stationary</i>
	<i>lns₃</i>	-5.9872	< 0.01	<i>Stationary</i>
	<i>lne₁</i>	-6.9094	< 0.01	<i>Stationary</i>
	<i>lne₂</i>	-8.0191	< 0.01	<i>Stationary</i>
	<i>lne₃</i>	-5.7382	< 0.01	<i>Stationary</i>
<i>Russia</i>	<i>lns₁</i>	-8.5018	< 0.01	<i>Stationary</i>
	<i>lns₂</i>	0.032211	0.99	<i>Non-stationary</i>
	<i>lns₃</i>	-2.9284	0.1849	<i>Non-stationary</i>
	<i>lne₁</i>	-8.3174	< 0.01	<i>Stationary</i>
	<i>lne₂</i>	-6.7752	< 0.01	<i>Stationary</i>
	<i>lne₃</i>	-8.295	< 0.01	<i>Stationary</i>

Source: own elaboration

As can be seen from the results above, the p-value of the logarithm series of the stock market of China and Russia during the pandemic era and Russia-Ukraine conflict periods and the stock market of the EU during the pre-COVID period are too high to refuse the null hypothesis, thus some time series data are not stationary. This thesis then applies log-difference to get the returns of stock markets and US foreign exchange markets to test the stationarity, stock market return of the Pre-COVID, Pandemic Era and Russia-Ukraine conflict periods are respectively represented by r_{s1} , r_{s2} and r_{s3} , while the US foreign exchange market returns of the aforementioned time intervals are represented by r_{e1} , r_{e2} and r_{e3} . The stationarity test results are shown in Table 3 below.

Table 4
Stationarity Test Results

Economic Entity	Variable	ADF Statistic	P-value	Conclusion
<i>China</i>	r_{s1}	-12.135	< 0.01	<i>Stationary</i>
	r_{s2}	-8.8539	< 0.01	<i>Stationary</i>
	r_{s3}	-6.3993	< 0.01	<i>Stationary</i>
	r_{e1}	-13.281	< 0.01	<i>Stationary</i>
	r_{e2}	-12.697	< 0.01	<i>Stationary</i>
	r_{e3}	-9.8173	< 0.01	<i>Stationary</i>
<i>EU</i>	r_{s1}	-8.4577	< 0.01	<i>Stationary</i>
	r_{s2}	-13.215	< 0.01	<i>Stationary</i>
	r_{s3}	-9.9491	< 0.01	<i>Stationary</i>
	r_{e1}	-13.022	< 0.01	<i>Stationary</i>
	r_{e2}	-12.364	< 0.01	<i>Stationary</i>
	r_{e3}	-0.3456	< 0.01	<i>Stationary</i>
<i>Russia</i>	r_{s1}	-13.948	< 0.01	<i>Stationary</i>

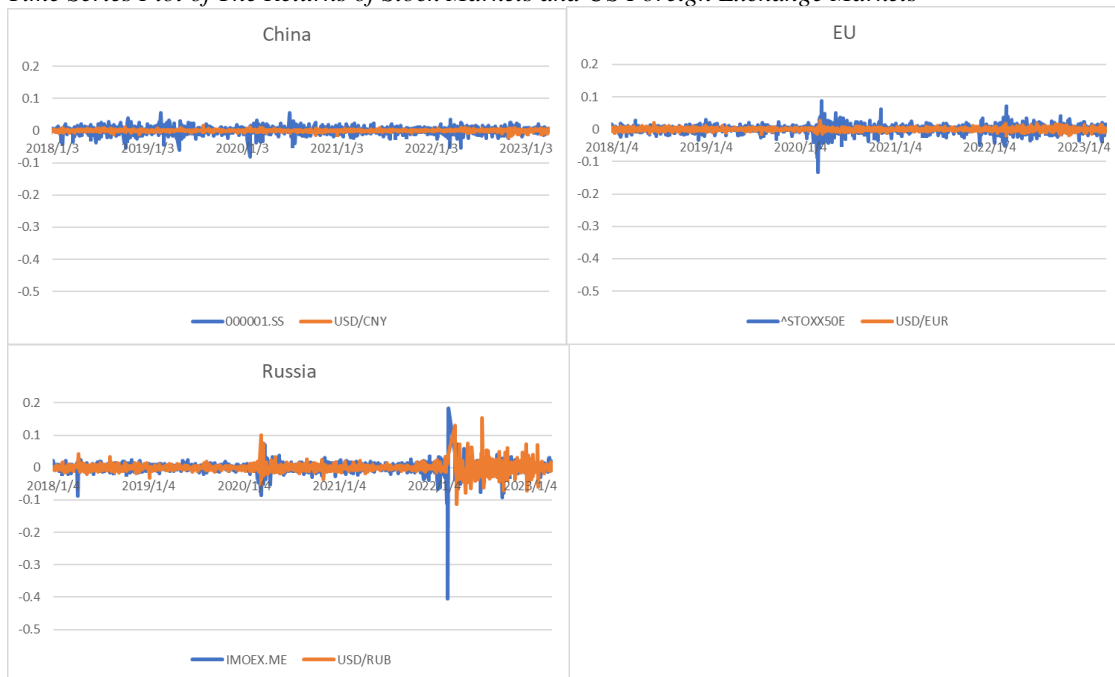
	r_{s2}	-4.4625	< 0.01	Stationary
	r_{s3}	-6.158	< 0.01	Stationary
	r_{e1}	-12.48	< 0.01	Stationary
	r_{e2}	-11.53	< 0.01	Stationary
	r_{e3}	-11.801	< 0.01	Stationary
Source: own elaboration				

As can be seen from the results above, after applying log-difference, the series of returns of the stock markets of all three economic entities and US exchange market towards them of all time are stationary. Under this circumstance, the series of the returns of stock markets and US exchange markets meet the condition for building VAR models.

Before proceeding to further analyze the returns of the stock market and US foreign exchange market, the time series of the returns of stock markets and US foreign exchange markets were plotted in Figure 4 below to visualize the difference. The maximum and minimum of the Y axes are unified according to the most fluctuant markets, which are related to Russia, to demonstrate the difference among the returns of markets.

Figure 4

Time Series Plot of The Returns of Stock Markets and US Foreign Exchange Markets



Source: own elaboration

It can be observed that the returns of the stock markets in all three economic entities are more fluctuant than the returns of the US foreign exchange rate market against them, as

the ranges are bigger. The return of the stock market in China has been more fluctuant before the outbreak of the Russia-Ukraine conflict, on the contrary, the returns of the exchange rate of USD/CNY show more volatility afterward. The returns of the stock market in the EU seem to be more fluctuant after the outbreak of the COVID-19. The returns of both markets related to the EU and Russia significantly fluctuate at some important points mentioned above, such as the outbreak of the COVID-19, and more fluctuant during the Russia-Ukraine conflict. The returns of both markets related to Russia are more fluctuant than in the other two economic entities, especially the return of the exchange rate of USD/RUB, which remained fluctuant after the outbreak of the Russia-Ukraine conflict but steadily weakened as the range gets smaller and smaller.

3.4 General Descriptive Statistics

To have basic support for further analysis later in this thesis, descriptive statistics are performed on the stock market and exchange rate market returns. Studying the change and regularity can provide a preliminary understanding of the sample. The descriptive statistic results are shown in Table 4 below.

Table 5 <i>Descriptive Statistic Results</i>						
Economic Entity	Variable	Mean	S.D.	Skew	Kurtosis	J-B Statistic
<i>China</i>	r_{s1}	-0.000194	0.012055	-0.13	16.89	5787.1852*
	r_{s2}	0.000238	0.011085	-0.83	7	1129.0014*
	r_{s3}	-0.000175	0.01075	-0.78	3.57	173.5173*
	r_{e1}	0.000148	0.002874	0	5.88	702.8011*
	r_{e2}	-0.000186	0.002498	-0.1	7.18	1124.6207*
	r_{e3}	0.000316	0.004157	0	7.28	604.2869*
<i>EU</i>	r_{s1}	0.000133	0.008461	-0.45	1.15	45.1995*
	r_{s2}	0.000107	0.015792	0.14	9.55	2086.2361*
	r_{s3}	0.000295	0.014413	-0.09	9.16	837.2726*
	r_{e1}	0.000153	0.003964	-0.03	1.5	47.6872*

	r_{e2}	-0.016158	0.004179	-0.14	7.26	1205.3151*
	r_{e3}	0.000136	0.00636	0	6.48	420.075*
<i>Russia</i>	r_{s1}	0.000709	0.009157	-0.1	6.41	847.4891*
	r_{s2}	0.015881	0.015567	-7.76	138.78	441272.131*
	r_{s3}	-0.00089	0.033274	-0.76	4.92	290.396*
	r_{e1}	0.000155	0.006992	0.01	0.81	13.9192*
	r_{e2}	0.000481	0.010155	0.07	3.24	238.9331*
	r_{e3}	-0.00015	0.0288	-0.04	14.03	2148.6491*
<i>Note.</i> Results marked with a single asterisk (*) denote statistical significance at p=0.01 level.						
Source: own elaboration						

In terms of the mean value, all the results being close to zero indicate that the stock markets in all three economic entities and the US foreign exchange rate markets towards them are relatively stable in the long term. Being positive or negative indicates whether the market has an upward trend or a downward trend during the corresponding time interval. Considering China, the major events that happened during the pre-COVID period and the Russia-Ukraine conflict showed a negative influence on the stock market, whereas, during the pandemic era, there was an upward trend. The influence on the exchange rate's return, on the contrary, is completely the opposite. As for the EU, during the pandemic era, the stock market obviously received influence from the COVID-19 pandemic since the average value gets smaller, furthermore, the return of the exchange rate of USD/EUR showed a downward trend, due to a weakening dollar. It is worth mentioning that the absolute value of the average return of the exchange rate during the pandemic era has greatly increased, which also indicates that the influence was strong. In the case of Russia, the COVID-19 pandemic has brought an upward trend to its stock market, but the Russian-Ukrainian conflict then negatively influenced the returns of the stock market and the exchange rate of USD/RUB. It's also worth mentioning that the absolute value of the average return of the stock market during the pandemic era was higher than the other two time intervals.

In terms of the standard deviation, which indicates the volatility and risk level of the markets, it can be observed that for all three economic entities, the standard deviation of the stock market return is larger than that of the exchange rate return during the same time interval. The standard deviation of stock market returns in China is almost ten times larger than that of the exchange rate of USD/CNY, and it's modestly getting smaller and smaller throughout the time of observation, whereas the exchange rate during the Russia-Ukraine conflict is more fluctuant than ever, having almost doubled compared with the other two

time intervals. As for the EU, the volatility and market risk of the stock market greatly increased because of the outbreak of the COVID-19 pandemic, and then slightly decreased a little bit during the Russian-Ukrainian conflict, while the exchange rate of USD/EUR shows more volatility and higher market risk after the outbreaks of the two major events, especially the latter one. The standard deviation of the stock market returns in Russia is also almost ten times larger than that of the exchange rate of USD/RUB. The returns of both markets related to Russia also reveal more volatility and market risk after the outbreaks of the two major events, especially the Russia-Ukraine conflict, both standard deviations doubled compared with the former time interval. The notable change can also be seen in the plots above.

In terms of skewness and kurtosis, the distribution of stock market return in China has always been left-skewed, and so is in Russia, the distribution of the US foreign exchange market towards them return was also left-skewed during the pandemic era, but during the other two time intervals, its distribution was symmetrical. The distribution of the stock market return of the EU was left-skewed during the pre-COVID and Russian-Ukrainian conflict periods, but it changed to right-skewed during the pandemic era. The distribution of its exchange rate return has been left-skewed until the outbreak of the Russian-Ukrainian conflict; it then became relatively symmetrical. The distribution of the exchange rate return in Russia has been right-skewed until the outbreak of the Russian-Ukrainian conflict, it then became left-skewed. As for kurtosis, the kurtoses of the stock market return of China and the return of US foreign exchange rate markets towards China are greater than three, indicating a leptokurtosis distribution. The kurtoses of the stock market return and US foreign exchange market return of the EU during the pre-COVID period are less than 3, indicating a platykurtic distribution, but greater than three during the pandemic era and Russian-Ukrainian conflict period, indicating a leptokurtosis distribution. The kurtosis of the stock market return of Russia is always greater than three, indicating a leptokurtosis distribution, but the kurtosis of the US foreign exchange market return during the pre-COVID period is less than 3, which indicates a platykurtic distribution.

In terms of JB statistics, the returns of both markets of all three economic entities refuse the null hypothesis of normal distribution at the confidence level of 1% of all time, the JB statistics are significantly greater than 0, which means that none of the return of any market in any economic entity follows the normal distribution at any interval of time.

To summarize, comparing the time intervals, during the pre-COVID era, the stock market returns of China were more fluctuant than in other periods, but the influence was negative. The returns of the stock market and exchange rate related to the EU and Russia were respectively steadier than in other periods. After the outbreak of the COVID-19 pandemic, there was a significant increase in the absolute value of the average return of the exchange rate of USD/EUR and the stock market related to Russia, indicating the influence was strong, though the directions are opposite, it was negative on the exchange rate of USD/EUR and positive for the stock market returns of Russia. The stock market returns in the EU were more fluctuant then ever. The outbreak of the Russia-Ukraine conflict brought a downward trend in the stock market returns of China and Russia, and the exchange rate of USD/RUB. During this time interval, the volatility was higher than ever for the returns of all exchange rates and the stock market returns in Russia. The influence received in the stock market returns of China and Russia and the exchange returns of USD/RUB were negative. The distributions of the returns in both markets in all economic

entities were left-skewed or became left-skewed after the outbreak of the two major events. What is more, the distribution is always leptokurtosis afterward, no matter whether it is platykurtic or not during the pre-COVID period. Lastly, none of the returns of any market in any economic entity follow the normal distribution at any interval of time.

4 DATA ANALYSIS

4.1 Correlation Analysis

After having a preliminary understanding of the sample, this thesis studies the correlation between the stock market in the economic entity and the US foreign exchange rate markets towards it and its change after the outbreak of the COVID-19 pandemic and Russian-Ukrainian conflict. The correlation coefficient results are presented in Table 5 below.

Table 6 <i>Correlation Coefficient Results</i>			
Economic Entity	Time Interval	Correlation	P-value
<i>China</i>	<i>Pre-COVID</i>	<i>0.03453144</i>	<i>0.4494</i>
	<i>Pandemic Era</i>	<i>-0.002088724</i>	<i>0.9622</i>
	<i>Russia-Ukraine conflict</i>	<i>-0.1164556</i>	<i>0.05691</i>
<i>EU</i>	<i>Pre-COVID</i>	<i>-0.001311426</i>	<i>0.9768</i>
	<i>Pandemic Era</i>	<i>-0.03421527</i>	<i>0.4262</i>
	<i>Russia-Ukraine conflict</i>	<i>-0.0744359</i>	<i>0.2567</i>
<i>Russia</i>	<i>Pre-COVID</i>	<i>0.05004977</i>	<i>0.2693</i>
	<i>Pandemic Era</i>	<i>-0.03221056</i>	<i>0.4555</i>
	<i>Russia-Ukraine conflict</i>	<i>-0.1629425</i>	<i>0.008872</i>
Source: own elaboration			

The results indicate that, at the 10% significance level, only the correlations between stock markets in China and Russia and the US foreign exchange rate markets towards them during the Russia-Ukraine conflict are significant. The standard deviation of the exchange rate of USD/CNY during the Russia-Ukraine conflict, as discussed before, almost doubled compared to that of the other two time intervals. On the other hand, the standard deviations of the stock market and the exchange rate related to Russia also doubled at the same time. Therefore, it can be concluded that a significant increase in the volatility can create correlations between the stock market and the exchange rate.

4.2 Granger Causality Test

Based on the results of the relevance analysis, this thesis then studies the Granger causality test, which is used to analyze whether the time series X influences predicting another time series Y, and if so, the time series X is the Granger cause of the time series Y. There are two null hypotheses of Granger causality test in this thesis, HO_1 represents that the stock market is not the Granger cause of the US foreign exchange market, whereas HO_2 represents that the US foreign exchange market is not the Granger cause of the stock market. The Granger causality test results are shown in Table 8 below.

Economic Entity	Time Interval	Null Hypothesis	P-value	Conclusion
China	Russia-Ukraine conflict	HO_1	0.4775	Accept HO_1
		HO_2	0.6513	Accept HO_2
Russia	Russia-Ukraine conflict	HO_1	0.02818	Reject HO_1
		HO_2	0.01177	Reject HO_2
Source: own elaboration				

As can be seen from the results above, in terms of China, during the Russia-Ukraine conflict era, both HO_1 and HO_2 can not be rejected, meaning that there is no Granger causality between the stock market in China and the exchange rate of USD/CNY. As for Russia, the outbreak of the Russia-Ukraine conflict creates bidirectional Granger causality between the stock market in Russia and the exchange rate of USD/RUB. Having correlations does not necessarily mean there's a Granger causality.

4.3 Time Series of Stock Indices Expressed In USD

This previous analysis has demonstrated the linkage between the stock markets and US foreign exchange markets against the corresponding economic entities, it is now necessary to study the returns of all stock indices expressed in USD in terms of investments. The S&P 500 Index (symbol: ^SPX) represents the US, the Shanghai Composite Index (symbol: 000001.SS) represents China, multiplied by the exchange rate of USD/CNY, the Euro STOXX 50 Index (symbol: ^STOXX50E) represents the EU, multiplied by the exchange rate of USD/EUR and the MOEX Russia Index (symbol: IMOEX.ME) represents Russia, multiplied by the exchange rate of USD/RUB. In this way, the factor of the exchange rate is considered in the analysis, because if an US investor wants to invest in the overseas stock markets, he has to consider the risks coming from the exchange rate. The time series of the US stock market and other stock markets expressed in USD can be seen from Figure 5 below.

Figure 5

Time Series Plot of US Stock Market and Other Stock Markets Expressed in USD



Source: own elaboration

The fluctuations in the stock markets in the US and the EU are remarkably similar, with some common upward and downward trends at some points. Taking a closer look at the general trends in the stock market in Russia, it can be found quite like the US stock market, but with much more potential and risks at the same time when considering investing in it. The stock market in China is the most stable one among all, the low correlation between the Chinese stocks market and other stock markets, due to a different monetary policy direction and a different growth model from other economies, allow investors to diversify their asset allocation.

4.4 General Descriptive Statistics

To get a more precise conclusion, this paper analyzes the descriptive statistic results on the stock markets' returns, using the same log-difference method as used above. The results are shown in Table 9 below.

Table 8 <i>Descriptive Statistic Results</i>					
Economic Entity	Time Interval	Mean	S.D.	Sharpe Ratio	Maximum Drawdown
<i>US</i>	<i>Pre-COVID</i>	<i>0.000361</i>	<i>0.009444</i>	<i>0.000118</i>	<i>13.92%</i>
	<i>Pandemic Era</i>	<i>0.000496</i>	<i>0.016295</i>	<i>-0.006614</i>	<i>14.00%</i>
	<i>Russia-Ukraine conflict</i>	<i>-0.00010</i>	<i>0.014667</i>	<i>0.032640</i>	<i>13.97%</i>

<i>China</i>	<i>Pre-COVID</i>	<i>-0.03090</i>	<i>0.012259</i>	<i>-0.028852</i>	<i>4.74%</i>
	<i>Pandemic Era</i>	<i>0.045745</i>	<i>0.011123</i>	<i>0.004008</i>	<i>4.70%</i>
	<i>Russia-Ukraine conflict</i>	<i>0.046767</i>	<i>0.010944</i>	<i>0.060670</i>	<i>9.24%</i>
<i>EU</i>	<i>Pre-COVID</i>	<i>0.000286</i>	<i>0.009015</i>	<i>0.000237</i>	<i>6.91%</i>
	<i>Pandemic Era</i>	<i>0.056024</i>	<i>0.016633</i>	<i>0.040856</i>	<i>5.06%</i>
	<i>Russia-Ukraine conflict</i>	<i>0.000431</i>	<i>0.015872</i>	<i>0.000360</i>	<i>7.00%</i>
<i>Russia</i>	<i>Pre-COVID</i>	<i>0.000864</i>	<i>0.011521</i>	<i>0.000904</i>	<i>4.65%</i>
	<i>Pandemic Era</i>	<i>0.000505</i>	<i>0.017167</i>	<i>0.000477</i>	<i>4.64%</i>
	<i>Russia-Ukraine conflict</i>	<i>-0.00104</i>	<i>0.045069</i>	<i>0.000438</i>	<i>5.42%</i>
Source: own elaboration					

In terms of the mean value, all the results being close to zero indicate that the stock markets in all three economic entities and the US foreign exchange rate markets towards them are relatively stable in the long term. Considering the US and Russia, the COVID-19 pandemic only brought slight changes in the average returns, they remained positive afterward. Yet the Russia-Ukraine conflict indeed had negative influences on their stock markets, especially in Russia, where the absolute value of the average return of the stock market almost doubled compared to that of the previous time interval, indicating that the influence was strong. Considering China, average return of the stock market during the pre-COVID era showed a downward trend, indicating that the major event happened at that time, the US-China trade war, had negative influence on its stock market. Nevertheless, during the pandemic era and Russia-Ukraine conflict era, there exists an upward trend. The stock market returns in the EU have been stable, in the sense that the mean value has always been positive. It is worth mentioning that under the influence of the COVID-19 pandemic, the average return significantly increased.

Data from this table can be compared with Table 5, which shows that the opposite influence received in the returns of the stock market and exchange rate can be offset. For example, the trends in the returns related to China have always been the opposite, but only during the pre-COVID era was the average stock market return expressed in USD negative. Although the average exchange rate return of USD/EUR was negative during the pandemic era, and the average stock market return in the EU was positive, the European stock market's average return expressed in USD was positive.

In terms of the standard deviation, the stock market return in the US and EU is more fluctuant during the pandemic era than in other time intervals. The standard deviation of the stock market return in China became smaller and smaller, indicating that for China, the risk level of the stock market return caused by the US-China trade war was the highest, followed by the COVID-19 pandemic. As for Russia, the standard deviation of stock market return related to it is the opposite of that of China, it is more fluctuant during the Russia-Ukraine conflict era, followed by the pandemic era.

Compared with the descriptive statistic results presented in Table 5 above, it can be observed that the trends in the standard deviations of the stock market return expressed in its original currency and in USD are consistent, indicating that the exchange rate does not affect the volatility.

In terms of Sharpe ratio, which measures the excess return per unit of risk taken by the index, the higher the better. The Sharpe ratio of the stock market returns in the US during the Russia-Ukraine conflict is better than other time intervals, so is China. Considering the EU, the Sharpe ratio of the stock market returns related to it after the outbreak of the COVID-19 pandemic became better. The Sharpe ratio of the stock market returns in Russia remains relatively stable; the best performed period of time is the pre-COVID era.

In terms of maximum drawdown, a smaller maximum drawdown refers to a more resilient index to risk when it depreciates. The maximum drawdown of the stock market return related to the US are at a high level, in comparison, the maximum drawdown of the stock market return related to Russia are at a relatively low level. The maximum drawdown of the stock index of China and the EU are also better than that of the US, but the Russia-Ukraine conflict made them less resilient than before.

In brief, the mean values, and the standard deviations of the returns of the stock indices in different economic entities at different times are different, depending on the influence they received from the major events that happened during that time. However, after combining the effect on the stock market and exchange rates, the influence can be offset. It is also observed that the trends in the standard deviations of the stock markets' returns expressed in their original currency are consistent as expressed in USD. The better Sharpe ratios are different for all stock indices at various times, but after the comparison of maximum drawdown, it's suggested to consider investing outside of the US.

5 CONCLUSION

This first aim of this thesis is to study the linkage between stock indices and exchange rates, the conclusions of previous studies clarify that there should be some linkage in terms of the correlation and Granger causality, thus this thesis continues to analyze the returns of the two variables for the selected period of time. After studying the average return and standard deviation, it's observed that the returns of the stock market and exchange rate related to China are negatively influenced by the major events during the pre-COVID era and Russia-Ukraine conflict era, the returns of the exchange rate related to the EU are mainly influenced by the COVID-19 pandemic, whereas both returns related to Russia are negatively influenced by the Russia-Ukraine conflict. Significant increases in the volatility create correlations between the stock market and the exchange rate related to China and Russia. However, only between the stock market and the exchange rate related to Russia exist bidirectional Granger causality.

The second aim of this thesis is to study the US stock market and other stock markets expressed in USD, it is confirmed that the influence received by the returns of the stock market and the corresponding exchange rates can be offset. What is more, the trends of the volatility of the returns of the stock markets in their original currencies are consistent as expressed in USD. After comparing the maximum drawdown, it is suggested that instead of investing in the stock market in the US, the stock market returns in China, the EU, and Russia are more resilient to risks. But before choosing the market to invest in, it is important to consider the degree of involvement and the type of influence received from the ongoing major event, where this event starts from and the relationship between the country in the center of the event and the one to invest in should be valued.

Other results are complicated because all the economic entities selected to be investigated in this thesis are large and unique, they are originally very different from each other, and their involvement in every major event mentioned are not the same. Therefore, the stock markets and the exchange rate of USD against other currencies receive influences from diverse sources and at different levels. Thus, when a major event happens, it is important to first consider the degree of involvement of the country of investment before making any decisions, the more involved, the higher the volatility and the market risk.

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ANNEXES

```
getwd()
setwd("F:/")
install.packages("psych")
install.packages("fBasics")
install.packages("tseries")
install.packages("vars")

# Read the merged data from the stock market and corresponding exchange rates (except for
the US)
data_U <- read.csv("USA.csv",dec = ",",sep = ';')
U1<-data_U[1:502,]
U2<-data_U[503:1042,]
U3<-data_U[1043:1318,]
data_C <- read.csv("CHINA.csv",dec = ",",sep = ';')
C1<-data_C[1:483,]
C2<-data_C[484:1001,]
C3<-data_C[1002:1270,]
data_E <- read.csv("EU.csv",dec = ",",sep = ';')
E1<-data_C[1:497,]
E2<-data_C[498:1041,]
E3<-data_C[1042:1276,]
data_R <- read.csv("RUSSIA.csv",dec = ",",sep = ';')
R1<-data_R[1:490,]
R2<-data_R[491:1030,]
R3<-data_R[1031:1288,]

# Pre-processing data (take China, first time interval as an example; not applicable for the US)
C1$Date <- as.Date(C1[, 1], format = "%d/%m/%Y")
C1$log_index <- log(as.numeric(gsub("\\.", "", gsub(";", ".", C1[, 2])))
C1$log_rate <- log(as.numeric(gsub("\\.", "", gsub(";", ".", C1[, 3])))
index_C1 <- diff(C1$log_index)
rate_C1 <- diff(C1$log_rate)

# General Descriptive Statistics
library(psych)
library(fBasics)
mean(index_C1)
describe(index_C1)
jarqueberaTest(index_C1)
mean(rate_C1)
describe(rate_C1)
```

```
jarqueberaTest(rate_C1)
```

```
# Stationarity test
```

```
library(tseries)
```

```
adf.test(index_C1)
```

```
adf.test(rate_C1)
```

```
# Relevance analysis
```

```
cor.test(index_C1, rate_C1)
```

```
#VAR model
```

```
library(vars)
```

```
index_rate_C1 <- cbind(index_C1, rate_C1)
```

```
VARselect(index_rate_C1, lag.max = 20, type = "const")
```

```
var_C1 <- VAR(index_rate_C1, p = 11, type = "const")
```

```
summary(var_C1)
```

```
causality(var_C1, cause = "index")
```

```
causality(var_C1, cause = "rate")
```

```
#Analysis of stock market returns (take China as an example)
```

```
C1$log_INDEX <- log(as.numeric(C1[, 2])*as.numeric(C1[, 3])) #Not applicable for the US
```

```
INDEX_C1 <- diff(C1$log_INDEX)
```

```
mean(INDEX_C1)
```

```
sd(INDEX_C1)
```

```
sharpe_ratio_C1 <- mean(INDEX_C1)/sd(INDEX_C1);sharpe_ratio_C1
```

```
maxdrawdown(C1$log_INDEX_C1)
```