Assessing the Impact of the Russia-Ukraine War on U.S. Stock Market: Event Study Analysis and Fuzzy Set Approach

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Abstract: *Although many studies take the event study and fuzzy set approach, there is a lack of studies on the impact of international conflict on different sectors within a country. This study uses this approach to calculate abnormal return and cumulative abnormal return to investigate the impact of the Russia-Ukraine war on the U.S. Stock Market of 20 representative companies of 10 U.S. sectors. Covering a 10-day timeframe before and 10-day window following the start of the war which was on 24 February, 2022, and the estimation window is set to 300 days. The research shows that the Russia-Ukraine war has a varied influence on each of the ten industries because of the U.S. sanctions against Russia, the companies in fast-moving consumer goods sector, healthcare sector, consumer discretionary sector, industries sector and materials sector are adversely affected, but energy sector, information technology sector, communication service sector and real estate sector are not affected by the war. Unlike others, the financial sector is most adversely affected.*

Keywords: *event study approach; abnormal return; cumulative abnormal return; Russia-Ukraine war; U.S. Stock Market; fuzzy set*

1. Introduction

The Russia-Ukraine war is a full-scale war in multiple militaries, political, economic, ideological, cultural, and cyber spheres. It is not only a regional war, but also an important historical moment for Russia to break through the NATO strategic squeeze, call out to the Western world, and pry the world's geopolitical tectonic plates. The war will affect the stock market by way of its uncertainty dampening market sentiment and causing damage to economic activity [1]. The geopolitical tensions due to the Russian-Ukrainian war, the current market sentiment is generally negative. Considering also the objective presence of global economic slowdown factors and the dominant position of the US in the global economy, analyzing the movements of the US stock market at the onset of the war becomes useful. We select a sample of 20 representative companies from 10 sectors: fast-moving consumer goods sector, energy, medical insurance, information technology, financial services, consumer discretionary, industries, materials, communication service, and real estate sector and study their changes on the day of the war. We define the event window as 10 days before and 10 days after the outbreak of the Russia-Ukraine war, and day 0 is regarded as the first day of the war. The estimation window is set to 300 days. As a result of the study, we find that among the 10 sectors, the first four sectors are affected to a relatively small extent and determine by the company's business area in the respective sector, but the Russia-Ukraine war is having a huge negative influence on the financial sector, which is trending downhill. On the study, there has little attention on the interpretation of the Russia-Ukraine war. In our report, we use stock data of 10 sectors, which is good to fill the gap in the research on its. Few studies have data from so many companies in different sectors and we can also combine these results of sectors to find their similarities and differences.

2. Literature review

Russia invaded Ukraine on 24 February 2022. At that time, the Russia-Ukraine war influenced the financial market immediately and there was great turbulence in the stock prices of some companies [2]. The data from Investing website show that generally lower bank stocks and insurance equities and the example is that Citibank lost 4.03% on 24 February 2022. However, the Russia-Ukraine war not only

influenced the stock market, but also had an impact on oil price, the medical sector, or other aspects. The established healthcare system has been severely damaged by the ongoing COVID-19 outbreak and the armed war [3]. Moreover, rising crude oil prices due to energy and fuel shortages have also had a big impact on transportation around the world [4].

In 1968, Ray Ball and Philip Brown invented the event study method [5]. The event study method has been applied to a wide range of economic events and it can reveal more important market trends or patterns. Previous study used this method to study effects on the economy of various forms of mergers and acquisitions in the renewable energy sector. The research was done in 2013 and in this paper, they focus on the change in CAR value [6]. We would combine the change of CAR and AR to analyse these sectors. Furthermore, the event window in this paper is like [-10,+15] and [-5,+5]. Our values are set more carefully, on a day-by-day basis. Kane did the study that what motives infer through the incentives for banking megamergers [7]. This paper mainly use t-value to analyse the data and these data are not enough. Binder also talked about the event study methodology since 1969 and there are some methods we do not mention in our work like Benchmark models and cross-sectional regression analysis [8]. Combining some of the methods used by previous authors, it is possible to derive the method we use now. They choose two values of CAR, AR ,t-value, p-value for comparison, but this is not enough. In our paper, we use these four data sets for comparison, which can lead to a much better conclusion. They have done the researches about what companies and sectors would be like after this thing happen. Their conclusions can also tell us that different sectors have different levels of being affected in different situations.

They research stock prices in many sectors in China during the COVID-19 epidemic using the event study method [9]. There is a report that promises to investigate the impact of the opening of the US stock markets on the German stock market [10]. Some researches employ the event study method to investigate the impact of certain events on the stock market and our work also focuses on the stock price of some sectors. Thus we choose to use this method rather than the other method. Some previous researches study the impact of some major events on the sectors. Some articles used this method show that the COVID-19 epidemic has an impact on the returns of the majority of Greek energy enterprises [11], global airline sector and shipping sector [12, 13]. Several studies show the impact and relationship between the event and one or two sectors. Compared to our research, we choose five various sectors and find the differences of AR and CAR between them. It can better show the relationship of these sectors and reveal the consequences of the Russia-Ukraine war. Prior researches have shown other events influence the stock market. Miyajima and Yafeh show that the banking crisis of Japan from 1995 to 2000 have a huge impact on the stock price of low-tech companies and the implications on the country will be felt for a long time [14]. Except for COVID-19 epidemic, researcher also do the study of SARS. According to a study, seven publicly traded hotel firms had large decreases in earnings and stock price during the SARS outbreak [15]. Many studies have been conducted utilizing the event study method to investigate the impact of various events such as the financial crisis, epidemic diseases [16], and so on. Due to the fact that war was still going on and just breaking out, there has not a lot of research on this period.

Some researches are similar to us and both yielded similar findings. Naidu and Ranjeeni use the data of 478 firms to study the Australian stock returns and discovered that investors in the Australian stock market did not react adequately to the coronavirus scare [17] . This article compares to our study in that they use more company data and larger event windows. And the difference is that this article focuses more on investors in the stock market, while we focus more on the development of the company and the sector itself. Some researchers used the GARCH model to discover that Covid-19 pandemic has had an impact on the union stock market as well as the sectoral indexes of sector, finance, and distribution. In our paper, we also choose two companies of finance and find the same result in the different period [18]. Some papers employed the event study method to do the researches about different companies and different countries like pharmaceutical companies in India, bank in Vietnam and consumer sector in China [19, 20, 21].

When they use event study method to do the research, they prefer to focus on one sector or one country. To date, this problem has received scant attention concerning the consequences of the Russia-Ukraine war on financial, technology, medical, energy, fast-moving consumer goods sector. It is a result that the work uses event study method to examine the influence on these sectors, which adds to current research.

3. Literature review

We select a representative sample of 20 companies from 10 sectors: fast-moving consumer goods, energy, medical insurance, information technology, financial services, consumer discretionary, industries, materials, communication services and real estate (Table 1). These companies play key leadership roles within their respective sectors and lead the sector as a whole. Since these companies are all listed on NASDAQ, as a result, the National Association of Securities Dealers Automated Quotations (Nasdaq) was chosen as its composite stock price index.

Table 1: Sample companies

Sector name	Company name	Company abbreviation
Fast-moving Consumer Goods (FMCG)	Kraft Heinz Co	KHC
	Walmart	WMT
Energy	Tesla	TSLA
	Valero Energy Corporation	VLO
Medical Insurance	Johnson & Johnson	JNJ
	Medtronic	MDT
Information Technology	Apple	APPL
	Microsoft	MSFT
Financial Services	Morgan Stanley	MS
	Citibank	C
Consumer Discretionary	McDonald's	MCD
	Nike	NKE
Industries	Corning	GLW
	Cummins	CMI
Materials	Vulcan materials Company	VMC
	Granite Construction Incorporated	GVA
Communication Service	Twitter	TWTR
	Meta	META
Real Estate	American Tower	AMT
	Prologis	PLD

First, since the time it takes for the market to accept an event is related to the size of the event, that is, the bigger the surprise, the longer the market will take to digest the impact of the event [22]. As a historic event that changed the world's geopolitical pattern and world order, the Russia-Ukraine war had a profound effect on all aspects. UN Secretary-General António Guterres said the effect of the Ukraine war on food, energy and finance was "systemic, severe and accelerating". Therefore, we designate the event window as starting 10 days before to the start of the Russia-Ukraine war and ending 10 days later, and day 0 is defined as the war day. The estimation window is set to 300 days. This not only gives efficient information processing cycles, but also reduces the likelihood of event confusion. To meet the requirement that the time horizon of the sample contains both estimation and event windows, the data selected on Investing contains 5050 data (505 observations each for companies and stock indices) from July 1, 2020, to July 1, 2022. Second, to determine the normal rate of return, we opt to use the market model. $R_{i,t}$ represents that stock i was returned on day t, $R_{m,t}$ represents the market's return on day t, and for every stock, carries out the following least squares OLS regression.

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \quad (1)$$

After obtaining the estimated coefficients $\hat{\alpha}_i$ and $\hat{\beta}_i$, set $\alpha_i = 0$, $\beta_i = 1$. Calculate the abnormal return (AR), which is the stock i's anomalous return on day t.:

$$AR_{i,t} = R_{i,t} - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t}) \quad (2)$$

Calculating the cumulative abnormal return(CAR) is also necessary to analyze how occurrences affect overall security pricing. $CAR_i(t_1, t_2)$ calculates the total of anomalous returns of company i during a specific time period from t_1 to t_2:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t} \qquad (3)$$

4. Data Analyse

Table 2: Abnormal returns of the sample companies

Period	KHC AR	WMT AR	TSLA AR	VLO AR	JNJ AR	MDT AR	APPL AR	MSFT AR	MS AR	C AR
-10	-0.40%	-0.76%	-2.59%	-0.11%	-0.35%	1.23%	-1.48%	0.15%	1.36%	0.61%
-9	-1.46%	-0.51%	0.69%	1.25%	-0.90%	-0.44%	0.10%	-0.73%	-0.53%	-0.24%
-8	1.88%	0.36%	0.22%	2.54%	-0.57%	-0.83%	1.43%	0.54%	-1.95%	-0.11%
-7	-0.44%	-1.01%	1.51%	-2.72%	-1.31%	-0.64%	0.02%	-0.14%	-2.14%	-1.16%
-6	-0.26%	-0.35%	0.92%	-1.90%	0.62%	0.86%	-0.48%	-0.60%	-0.18%	0.28%
-5	5.58%	-0.57%	0.05%	-0.77%	-0.08%	-0.67%	-0.08%	-0.30%	-2.37%	-0.17%
-4	3.76%**	4.88%	-0.19%	-0.97%	-0.19%	-0.49%	1.15%	-0.10%	-4.15%**	-2.96%
-3	1.99%***	-0.27%	-0.35%	-0.44%	-1.55%	-0.71%	0.36%	0.14%	-0.56%**	-0.79%
-2	4.75%***	-1.46%	-6.58%	-1.42%	-1.60%**	2.77%	-3.29%	-1.41%	-1.34%**	-0.72%
-1	-0.25%***	-0.28%	-2.82%	0.70%	0.41%*	0.13%	0.23%	-0.17%	-0.62%**	-0.73%
0	-3.48%**	-1.30%	-1.13%	-3.60%	-2.46%**	-0.67%	-2.13%	1.79%	1.79%	-4.71%*
1	1.60%***	0.99%	-1.63%	0.79%	4.71%	2.02%	-0.42%	-0.60%	2.28%**	1.79%
2	-1.36%**	-0.95%	6.75%	-1.88%	-0.94%	-0.86%	-0.23%	0.14%	-4.34%***	-4.61%**
3	-1.09%**	1.08%	1.78%	-3.47%	-0.15%	-0.77%	0.55%	0.17%	-3.11%***	-0.93%**
4	0.66%**	-0.30%	-1.20%	3.25%	0.95%	2.17%	0.18%	0.13%	0.11%***	1.27%*
5	2.52%**	2.75%	-2.28%	0.65%	1.66%	1.67%	1.41%	-0.05%	-0.39%***	-3.12%**
6	-0.03%**	2.95%	2.02%	2.08%	0.76%	1.05%	-0.35%	-0.78%	-1.37%***	-1.67%**
7	1.51%**	0.27%	2.19%	-2.01%	2.15%	-0.39%	1.77%	-0.21%	-2.33%***	-1.32%**
8	-3.65%*	-1.92%	2.97%	7.59%	-2.00%	-2.23%	-0.75%	-0.76%	-0.24%***	-1.26%**
9	-1.96%	-0.43%	-1.97%	-4.47%	-0.19%	-1.49%	-0.44%	1.14%	3.55%***	1.27%**
10	-1.48%	2.61%	-0.74%	2.71%	0.31%	1.21%	-1.54%	-0.01%	-1.60%***	-1.84%**

Table 2: (continued)

Period	MCD AR	NKE AR	GLW AR	CMI AR	VMC AR	GVA AR	TWTR AR	META AR	AMT AR	PLD AR
-10	-0.83%	0.65%	-0.62%	0.48%	1.14%	-0.92%	2.67%	3.01%**	0.82%	1.57%
-9	-0.37%	0.31%	0.20%	-0.51%	0.48%	-1.98%	0.94%	0.93%*	-1.82%	-3.39%
-8	0.43%	-1.39%	0.31%	0.22%	-0.40%	0.05%	0.69%	-0.08%	-0.74%	0.12%
-7	-0.74%	0.92%	-1.41%	-1.23%	-1.79%	0.52%	-0.42%	-0.92%	-1.15%	-0.81%
-6	-0.74%	1.31%	0.58%	0.83%	2.15%	0.91%	0.59%	-1.35%	-1.64%*	-1.23%
-5	-0.27%	0.64%	0.78%	0.46%	1.29%	-0.17%	-1.80%	-1.91%	-0.42%*	-0.91%*
-4	0.20%	-0.79%	-0.74%	-1.41%	-1.55%	-2.01%	1.61%	-0.60%	-0.08%	0.71%
-3	0.28%	0.78%	1.51%	-0.01%	-1.06%	0.68%	-1.53%	0.66%	0.50%	0.02%
-2	0.35%	-4.16%	-2.10%	-2.08%	-1.63%	-3.32%	-5.62%	-3.50%	-0.71%	-0.94%
-1	-1.04%	0.50%	-0.71%	-3.29%	-3.75%	-0.53%	2.80%	1.19%	0.89%	0.12%
0	-2.34%*	-1.79%	-1.16%	-1.94%*	0.16%	0.01%	2.63%	0.70%	0.17%	-0.07%
1	1.24%	0.25%	0.64%	-0.01%*	3.11%	-6.87%	-0.92%	-0.35%	0.04%	2.66%
2	-2.01%*	-1.85%	-1.85%	0.08%	-1.29%	-6.93%**	0.44%	-0.09%	-3.08%*	-2.03%
3	-1.56%**	-2.28%	-3.63%	-3.59%**	-3.60%	-7.01%***	2.10%	-1.73%	1.52%	0.66%
4	-0.06%**	1.60%	2.37%	5.29%	1.68%	3.75%**	-4.62%	0.36%	0.22%	0.31%
5	-1.27%**	-0.43%	0.37%	1.26%	-0.28%	-0.96%**	-1.31%	-0.74%	2.58%	1.98%
6	0.12%**	-1.31%	-1.20%	-3.02%	0.09%	2.27%**	1.52%	0.17%	1.97%	1.46%
7	-3.55%***	-2.96%	-1.91%	-5.34%**	-3.14%	-2.37%**	1.90%	-1.92%	-0.74%	0.60%
8	-0.56%***	-2.40%*	-0.61%	1.91%*	0.44%	5.81%	1.41%	1.99%	-1.55%	-1.18%
9	-1.42%***	2.62%	-0.14%	2.09%	2.47%	-0.56%	0.86%	0.25%	0.47%	0.41%
10	0.16%***	-0.12%	-1.02%	-0.37%	-0.64%	4.27%	0.73%	-0.38%	0.41%	0.87%

Note: This table presents the abnormal returns of the sample companies at different time windows. Denotes statistical significance at *** p <0.01, ** p<0.05, * p<0.1.

Our studies indicate that a number of sectors have been impacted by the start of the Russia-Ukraine war. We assume that the 10 days leading up to and following the event have the greatest impact on the company returns. The estimation window determines the event's impact, as shown in Table 2. The observed influence decreases as the estimation windows widen.

For fast-moving consumer goods sector, KHC is greatly affected by the war and the data show that WMT has not been much affected by the war. Table 2 shows that AR of KHC and WMT peaked at similar times. WMT is not much affected because all of the statistical significance is greater than 10%. AR of WMT peaks on the 4 days before the event and the maximum is 4.88%. AR of KHC reaches 4.75% at the 1% level of significance. On the day that the Russia-Ukraine war happens, AR of KHC reaches a low point that -3.48% at the 1% significance level and the lowest point is -3.65% at the 10% level of significance on the 8 days after the event. The trend after the event of WMT is similar to it before the event. On the 5 days and 6 days after the event, it has a positive impact on the AR of WMT.

On the 5 days after the event, the AR of KHC reaches 2.52% at the 5% significance level. As can be seen from Fig. 1 (a) and (b), CAR of KHC continues to be positive after 5 days before the event and CAR of WMT to be positive is the same as KHC. These two companies still have some differences because the main product of KHC is food and WMT is daily necessities. After the Russia-Ukraine war, all new investments by KHC were halted in Russia and WMT do not enter the Russian market. As a result, KHC is more affected than WMT and this also has a certain relationship with the types of products sold by two companies.
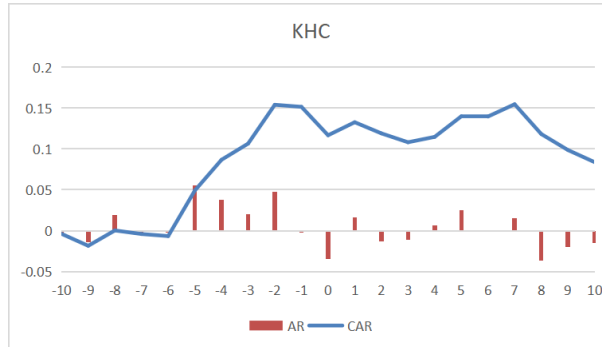
(a) KHC
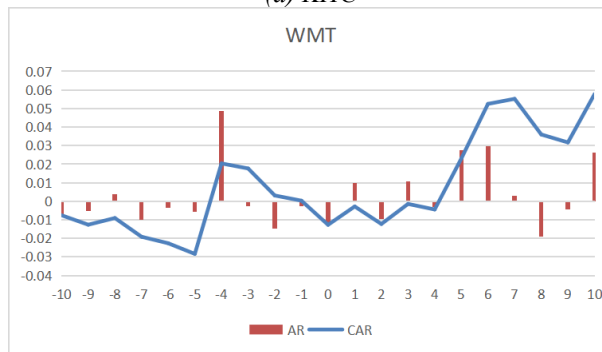
(b)WMT
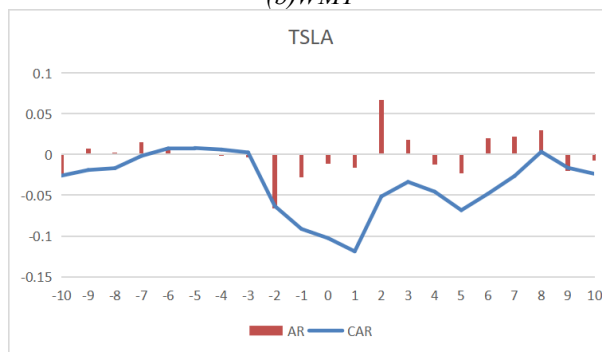
(c)TSLA
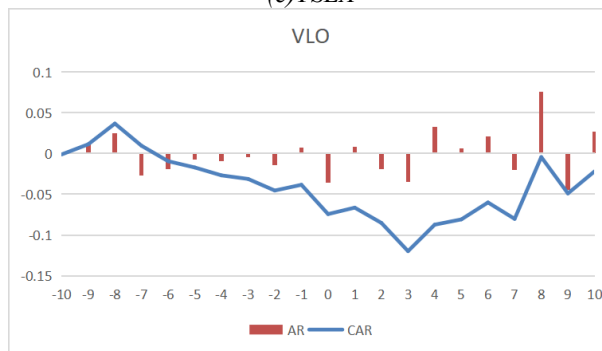
(d)VLO
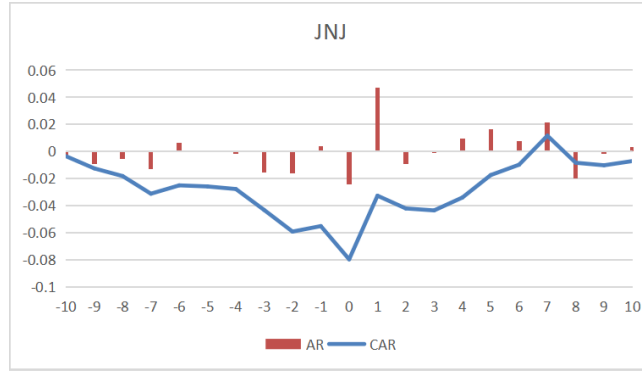
(e)JNJ

(f)MDT

(g)AAPL

(h)MSFT

(i)MS

(j)C

(k)MCD
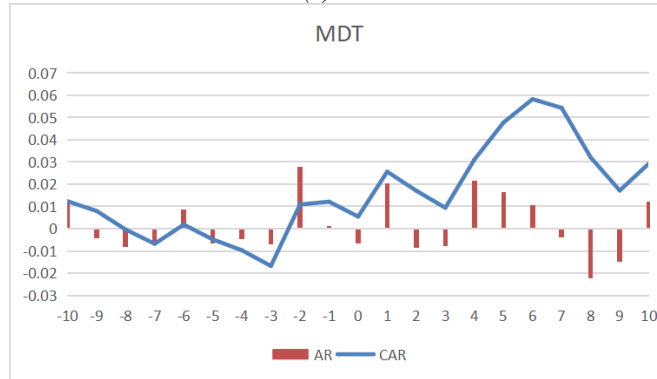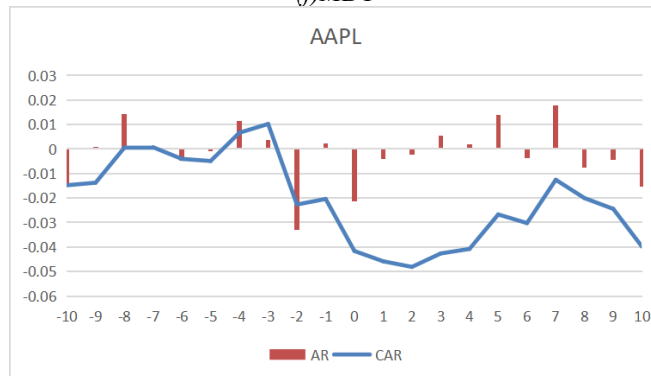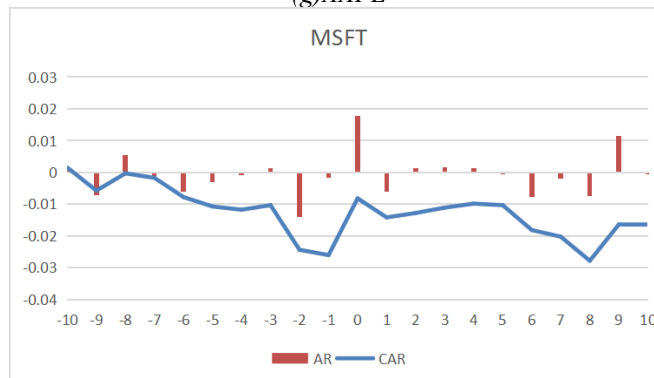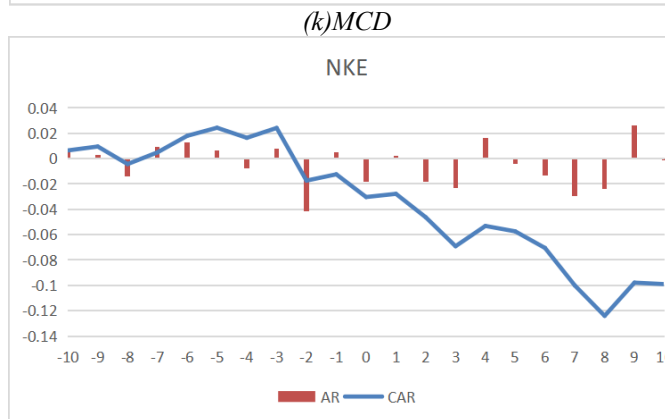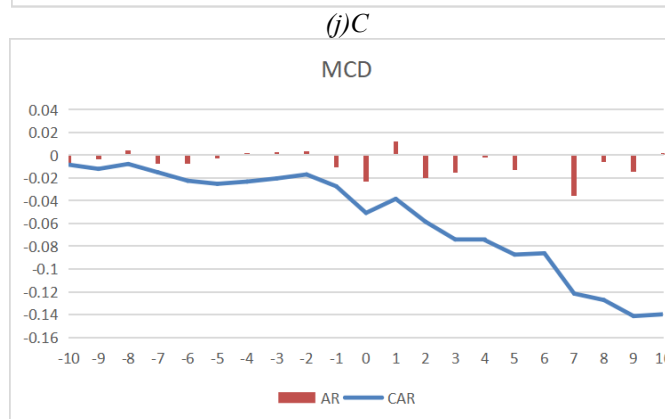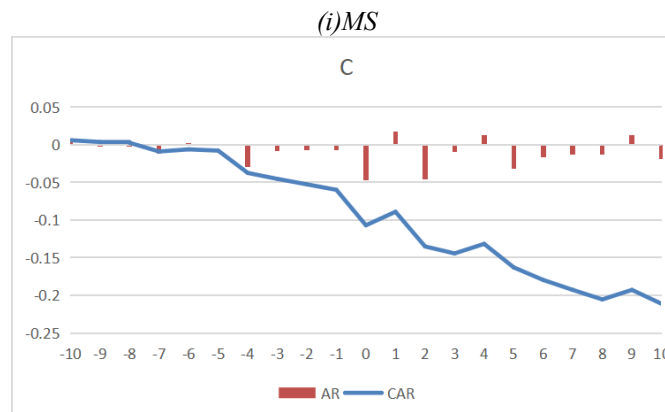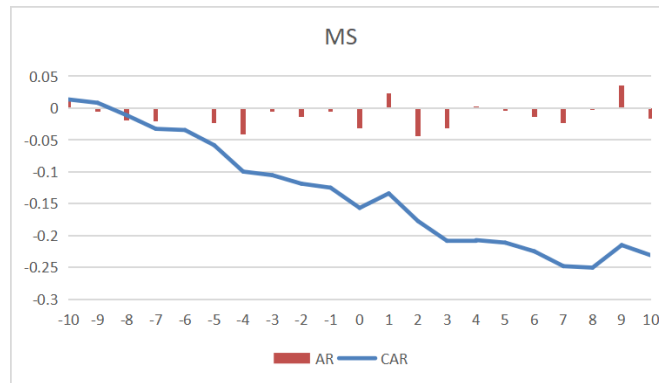
(l)NKE
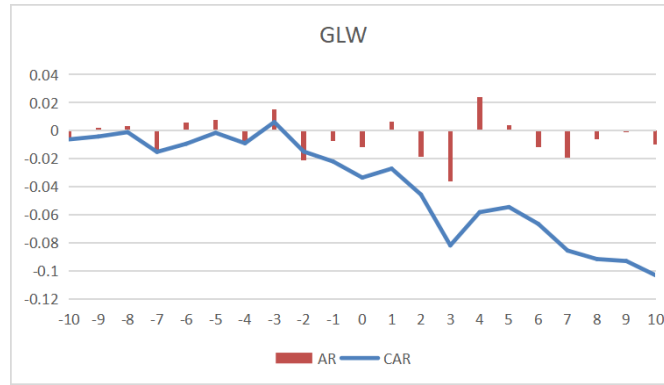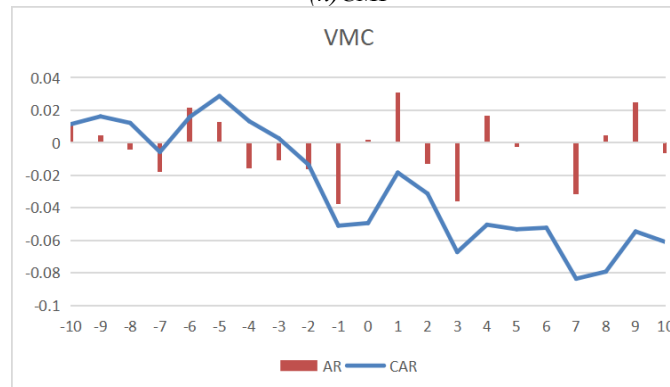
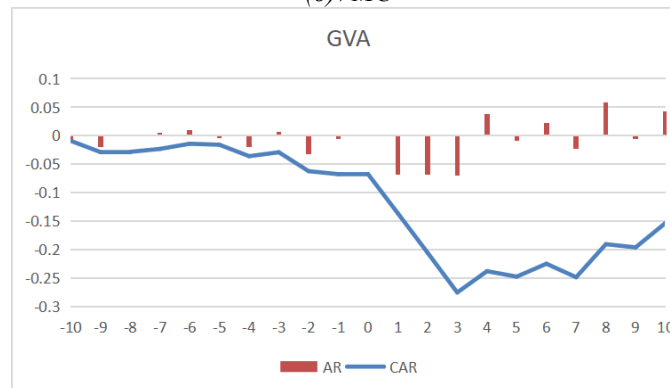*(m)GLW*

(n)CMI

(o)VMC

(p)GVA

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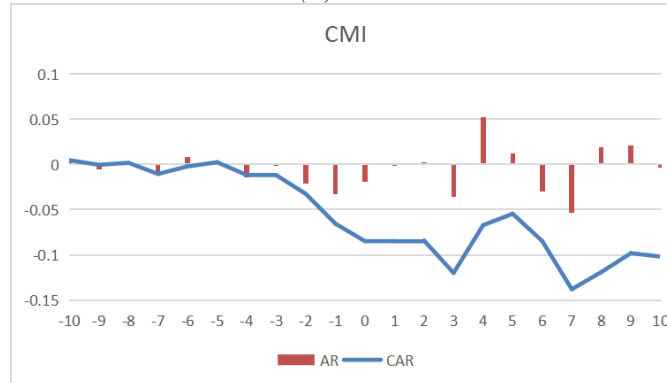
Figure 1: AR and CR for all indices calculated using the market model for 10 companies.

Compared to other sectors, the Russia-Ukraine war had little effect on the energy sector, but the energy sector was affected by other events. It can be seen intuitively that neither TSLA nor VLO had significant AR in the 20-day event windows from Table 2, which shows that although the Russia-Ukraine war has led to the US imposing energy sanctions on Russia, this will have little impact on the U.S. energy sector. The embargo on Russian crude oil, natural gas and other energy sources cannot affect TSLA, which is mainly engaged in sustainable energy. For VLO whose main business is oil refining, this may be because the United States has increased its exploitation of domestic oil in order to get rid of its dependence on imported oil, resulting in a surge in oil production since 2010 [23]. At the same time, for TSLA, in the first two days of the war, its AR reached the minimum value (-6.58%) in the entire Table 2 data, and two days after the outbreak of the war, TSLA's AR reached 6.75%, which is the maximum value of 20 days. For the VLO, on the 8th day after the war, its AR reached 7.59%,

which is the largest value in the entire data in Table 2, and on the subsequent 9th day, the AR of the VLO dropped to the lowest value in 20 days (-4.47%). Apart from that, it is clear from Fig. 1 (c) and (d) that the CAR curves of these two companies are more volatile. This shows that other factors had an impact on the energy sector in the 10 days before and after the Russia-Ukraine war, which may include changes in U.S. policy on the energy sector and an increase in investment. In general, the U.S. has prevented the onset of the Russia-Ukraine war from producing market volatility in the energy sector market by expanding domestic energy production [24].

The consequences of the Russia-Ukraine war for the healthcare sector has had different effects on different companies, with JNJ and MDT being the best examples. As can be seen from Table 2, the Russia-Ukraine war had certain negative consequences for the JNJ. Until three days before the war, at the 5% significance level, JNJ had an AR of -1.60%. On the occasion of the incident, the AR for JNJ reached a minimum value (-2.46%) at the 5% significance level. For MDT, its AR is not very significant within the event windows, which shows that the Russia-Ukraine war has no effect on MDT. From the CAR curves presented by the two companies in Fig. 1 (e) and (f), it is clear that the CAR curve of JNJ has a larger negative trend range, while MDT has a larger positive trend range. This directly results in the two companies in Fig. 1 (e) and (f) exhibiting different CAR curves. It is obvious that the negative trend range of the CAR curve is larger for the JNJ, while the positive trend range is larger for MDT, which may be related to the different main business areas of the two companies. The JNJ mainly develops medical devices, pharmaceuticals and consumer products, while the MDT focuses on medical technology, which is at the core of its business: helping clinical experts develop solutions for various treatments that affect the health of patients. The commencement of the Russia-Ukraine war has led to higher-cost transportation methods. For JNJ, it has increased the transportation cost of medical drugs and consumer goods. Secondly, Russia and Ukraine supply the majority of the world's raw materials used to make hospital equipment. Crude oil, natural gas and certain metals, while U.S. sanctions on resources such as Russia's crude oil have led to higher production costs for medical drugs. But for MDT, the war doesn't have an impact on medical technology. All in all, different health care companies will be affected differently by the Russia-Ukraine war due to costs. Although some companies' stock prices will fall due to the war, some companies will not be affected.

Compared with other sectors, the effect of the Russia-Ukraine war on the information technology sector was not large. From Table 2, it can be seen that the AR data of APPL and MSFT are not statistically significant. More importantly, as can be seen from the CAR trend lines in Fig. 1 (g) and (h), the stock prices of Apple and Microsoft did not fluctuate significantly in the 20 days before and after the war. Although Apple and Microsoft stopped operations and product sales in Russia after Russia invaded Ukraine, in fact, this did not cause much loss to the two companies. This may be because the main business of Apple and Microsoft is not only the retail of products, but also operating systems, office software, cloud services, computer hardware and software. Secondly, the main market for Apple and Microsoft is the Americas, and the loss of the Russian market did not bring much loss. In addition, affected by the Russia-Ukraine war, the society's increased demand for network security is also one of the important reasons. In short, the Russia-Ukraine war had no effect on the information technology sector.

The Russia-Ukraine war had the most negative impact on the financial sector of the 10 sectors. As can be seen from Table 2, the negative effects of war on MS were manifested in the first four days, and its AR reached -4.15% at the 5% significance level. Its negative path continued until the day of the Russia-Ukraine war, and at the 1% significance level, the MS had a negative AR of -3.18%. And C recorded the smallest AR (-4.71%) over the 20 days at the 10% significance level. A day after the incident, both companies had a brief recovery, and they both received positive AR, but this was quickly broken, and on the second day of the war, the MS was at 1% of the significant It achieved a negative AR at the susceptibility level and fell to a 20-day low (-4.34). C's AR achieves -4.16% at the 5% significance level. From Table 2, it can be seen that since the second day after the war, the AR of both companies showed the same trend and both were statistically significant, except that the AR showed positive on the fourth and ninth day of the war, Everything else is shown as negative. The AR of MS is at the 1% significance level, and the AR of C has reached 5% except for the 10% significance level on the fourth day. As can be seen from Fig. 1 (i) and (j), unlike other companies, the CAR of the two companies belonging to the financial sector showed a clear downward trend, because their primary lines of business were institutional securities, wealth management, and investment management, while the US Financial sanctions imposed on Russia in response to the invasion of Ukraine have significantly reduced options for financial services firms to sell Russian retail operations, and firms' exposure to Russia has adversely affected them. All in all, the financial sector was affected by the Russia-Ukraine war, and stock prices showed a downward trend.

For the consumer discretionary sector, different companies are affected by the Russia-Ukraine war differently. Table 2 clearly shows that MCD is continuously negatively affected from the day of the war outbreak. More importantly, the AR data significance level of MCD shows an increasing level. On the seventh day of the war , the AR hits the smallest value (-3.55%) in the twenty-day time span at the 1% significance level. And the CAR of Fig. 1 (k) has been decreasing, indicating that the war has an enormous negative impact on MCD. This is related to the fact that Russia and Ukraine account for approximately 9% of MCD's sales and 3% of operating income. MCD suspended its operations in Russia due to several sanctions imposed by the U.S. on Russia. At the same time, its restaurants in Ukraine were closed for an ex10ded period due to the war, but it is still committed to paying its employees in that country their total salaries. Although NKE also suspended all its operations in Russia due to the Russia-Ukraine war, it can be obtained from Table 2 that the AR of NKE only reached -2.40% at the 10% level of significance on the eighth day of the event out of twenty days, while the CAR curve in Fig. 1 (l) is less volatile, which indicates that the impact of the war on NKE is small compared to MCD. NKE's largest market is North America becomes the main reason for this result. In fact, NKE's sales in North America account for about 40% of its total revenue, and losing the Russian market does not significantly impact Nike. In conclusion, the impact of the Russia-Ukraine war on the consumer discretionary sector depends on the share of the Russian and Ukrainian markets in the company's sales. A large percentage will lead to a negative impact on the company.

The effect of the Russia-Ukraine war on the industries depends on the type of company. None of the AR of GLW shows statistical significance in Table 2, and the CAR curve in Fig. 1 (m) does not show significant fluctuations, which indicates that GLW is not affected by the event. As for CMI, the AR CMI reached -1.94% at the 10% level of significance on the day of the event, followed by 10 days of negative AR with higher significance levels one after another, and reached a negative AR of -5.34% at the 5% level of significance on the seventh day after the outbreak of the war, and several segments of the CAR curve with straight-line declines can be known from Fig. 1 (n). The other performance may be related to the difference in the central business. GLW specializes in technical research and manufacturing of ceramics, specialty glass and related materials. At the same time, CMI focuses on the design, manufacturing, distribution, and service of diesel and natural gas engines, which are negatively affected by the U.S. energy sanctions against Russia, which resulted in the supply of natural gas and diesel from Russia being cut off, raising the price of raw materials, which is similar to the findings of Javier and Pedro [25]. In general, the difference in the central business leads to differences in the impact of the war between Russia and Ukraine for different companies in the industries, where companies that rely on energy materials are negatively affected by the increase in costs.

Similar to the healthcare sector, consumer discretionary sector, and industries, the effect of the Russia-Ukraine war on the materials sector also depends on different companies. Table 2 shows that the AR of VMC is not highly significant within any 20-day event window. The CAR curve values in Fig. 1 (o) fluctuate only between (-0.08 and 0.03), indicating that the event's occurrence did not affect VMC. In contrast, statistically, significant AR appears within GVA from day 2 to day 7 of the war. Especially on day 2 and 3 day, its AR reaches -6.93% and -7.07% at the 5% and 1% significance levels, respectively, as can also be seen in Fig. 1 (p), where the CAR curve shows a linear decline between the day of the war outbreak and the third day after the war. Their different main business may cause this. VMC mainly produces, distributes, and sells construction materials, while GVA is more diversified. It focuses on transportation infrastructure projects in both public and private sectors, indicating that it needs more construction materials such as copper, steel, and aluminum. Russia is one of the critical suppliers. Energy sanctions lead to the cost increase of GVA's construction materials. In short, whether there is a significant change in raw materials costs is the main reason the Russia-Ukraine war will impact the materials sector, and companies whose raw materials needs fall within the main supply range of Russia are likely to be negatively affected by the war.

The effect of the Russia-Ukraine war on the communication services sector is little. The AR of META reached the maximum value (3.01%) at the 5% significance level on the 10 days before the event. META has not been greatly affected by the war and the AR reached the minimum value on the 2 days before the event. TWTR is also not affected a lot but the stock of TWTR had a large fluctuation during that period. The AR of TWTR reached the minimum value (-5.62%) on the 2 days before the event and the next day the AR then rises to 2.80%, which is also the maximum value during this period. On the 4 days after the event, the AR achieved -4.62%. TWTR was volatile during that time because Facebook's users continued to decline, causing its parent company META's market cap to drop considerably as well. In Feb 2022, TWTR declared that their board of directors had approved the acquisition of up to $4.0 billion worth of their common shares. Because of that, the stock change a lot in these days. From Fig.(q) and (r) we can see that he CAR of META become to be negative after 19

Feb, and TWTR has a positive CAR for most days. However, we can clearly see that the CAR fluctuation range of META is much larger than that of TWTR. Neither company was greatly affected by the war, but both saw their stocks fluctuate to some degree due to the company's own changes in decision making during these days. In conclusion, compared to other sectors, the Russia-Ukraine war has only slightly benefited the communication services industry, and other events have also had an impact.

For real estate sector, the sector does not seem to have been greatly affected by the war. On the 6 and 5 days before the events, the AR of AMT reached -1.64% and -0.42% at the 10% significance level. It also achieved the minimum value (-3.08%) on the 2 days after the war at the 10% significance level and the maximum value is 2.58% on the 5 days after the war. For PLD, the AR of this company reached -0.91% at the 10% level of significance on the 5 days prior the war. The maximum value of PLD is 2.66% and the minimum value is -3.39%. From Fig.(s) and (t) we can see that the CAR of these two companies is negative on most of these days and AMT has a slightly wider range of fluctuations than PLD. We can see they all belongs to real estate sector, but AMT belongs to real estate investment trusts sector and PLD belongs to industrial real estate sector. Both stock prices of companies did not fluctuate very significantly during these 20 days, with only a few days with small fluctuations up or down. All in all, real estate was not negatively affected by the Russia-Ukraine war.

5. Conclusion

This study incorporates event study methodology and the financial impact of the Russia-Ukraine war in 10 sectors. Our finding suggests that the impact of the Russia-Ukraine war stems primarily from the U.S. economic sanctions against Russia. The most obvious manifestation of this is the main adverse effect on the financial sector due to economic sanctions such as the inclusion of Russian central banks on the SDN list and the freezing of foreign exchange reserves of the central bank. This is consistent with the results of studies of financial markets during the international conflict [26]. The main business sectors not affect by economic sanctions, such as energy, information technology, communication services, and real estate, are not affected by the Russia-Ukraine war. Noteworthy is the fact that the stock volatility in the energy sector is significant, probably due to the continued downturn in the US stock market since COVID-19 and the outbreak of the Russia-Ukraine war in 2022, which indirectly led to a large number of investors losing confidence in the stock market as a high expected risk asset and shifting their funds to similar low risk investments such as gold. Different companies in the same sector are affected differently, where the presence of important markets in Russia and Ukraine is an important factor, and companies with a large share of sales can suffer from a severe stock decline due to the cessation of operations in these two countries (e.g., MCD). Another crucial element is whether a company's raw materials and transportation costs spike due to economic sanctions(e.g., JNJ, CMI, GVA). This is consistent with earlier research on the detrimental effects of armed warfare, sanctions, and boycotts on target companies involved in such events [27, 28, 29]. It is worth mentioning that the energy sector results differ from those of Antonakakis et al. [30], where the Russia-Ukraine war do not bring volatility because the United States increases its own energy extraction and thus reduces its energy dependence on Russia. This study has some limitations, mainly because we select only two firms to represent the performance of their sectors, which may generate selection bias.

References

[1] Market Realist. 2022. Debunking Myths about the Stock Market and War as Russia Invades Ukraine.

[2] Umar, Z., Polat, O., Choi, S.-Y., & Teplova, T. (2022). The impact of the Russia-Ukraine conflict on the connectedness of financial markets. Finance Research Letters, 102976. https://doi.org/10.1016/j.frl.2022.102976

[3] Uwishema, O., Sujanamulk, B., Abbass, M., Fawaz, R., Javed, A., Aboudib, K., Mahmoud, A., Oluyemisi, A., & Onyeaka, H. (2022). Russia-Ukraine conflict and COVID-19: a double burden for Ukraine's healthcare system and a concern for global citizens. Postgraduate Medical Journal, postgradmedj-2022-141895. https://doi.org/10.1136/postgradmedj-2022-141895

[4] Ozili, P. K. (2022). Global economic consequence of Russian invasion of Ukraine. Papers.ssrn.com. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4064770

[5] Ball, R., & Brown, P. (1968). An Empirical Evaluation of Accounting Income Numbers. Journal of Accounting Research, 6(2), 159–178. https://doi.org/10.2307/2490232

[6] Yoo, K., Lee, Y., & Heo, E. (2013). Economic effects by merger and acquisition types in the renewable energy sector: An event study approach. Renewable and Sustainable Energy Reviews, 26, 694–701. https://doi.org/10.1016/j.rser.2013.06.002

[7] Kane, E. J. (2000). Incentives for Banking Megamergers: What Motives Might Regulators Infer from Event-Study Evidence? Journal of Money, Credit and Banking, 32(3), 671. https://doi. org/10.2307/2601202

[8] Binder, J. (1998). The Event Study Methodology Since 1969. Review of Quantitative Finance and Accounting, 11(2), 111–137. https://doi.org/10.1023/a:1008295500105

[9] He, P., Sun, Y., Zhang, Y., & Li, T. (2020). COVID–19's Impact on Stock Prices Across Different Sectors—An Event Study Based on the Chinese Stock Market. Emerging Markets Finance and Trade, 56(10), 2198–2212. https://doi.org/10.1080/1540496x.2020.1785865

[10] Dimpfl, T. (2011). The impact of US news on the German stock market—An event study analysis. The Quarterly Review of Economics and Finance, 51(4), 389–398. https://doi.org/10.1016/j. qref. 2011.07.005

[11] Polemis, M., & Soursou, S. (2020). Assessing the Impact of the COVID-19 Pandemic on the Greek Energy Firms: An Event Study Analysis. Energy RESEARCH LETTERS. https://doi.org/ 10.46557/ 001c.17238

[12] Maneenop, S., & Kotcharin, S. (2020). The impacts of COVID-19 on the global airline industry: An event study approach. Journal of Air Transport Management, 89. https://doi.org/ 10.1016/j. jairtraman.2020.101920

[13] Gavalas, D., Syriopoulos, T., & Tsatsaronis, M. (2021). COVID–19 impact on the shipping industry: An event study approach. Transport Policy. https://doi.org/10.1016/j.tranpol.2021.11.016

[14] Miyajima, H., & Yafeh, Y. (2007). Japan's banking crisis: An event-study perspective. Journal of Banking & Finance, 31(9), 2866–2885. https://doi.org/10.1016/j.jbankfin.2007.03.006

[15] Chen, M.-H., Jang, S. (Shawn), & Kim, W. G. (2007). The impact of the SARS outbreak on Taiwanese hotel stock performance: An event-study approach. International Journal of Hospitality Management, 26(1), 200–212. https://doi.org/10.1016/j.ijhm.2005.11.004

[16] Mai, L. C. (2021). The Impact of COVID-19 on Stock Price: An Application of Event Study Method in Vietnam. Journal of Asian Finance, 8(5), 523-0531. https://doi.org/ 10.13106/jafeb. 2021.vol8.no5.0523

[17] Naidu, D., & Ranjeeni, K. (2021). Effect of coronavirus fear on the performance of Australian stock returns: Evidence from an event study. Pacific-Basin Finance Journal, 66, 101520. https://doi.org/10.1016/j.pacfin.2021.101520

[18] Zoungrana, T. D., Toé, D. L. tan, & Toé, M. (2021). Covid-19 outbreak and stocks return on the West African Economic and Monetary Union's stock market: An empirical analysis of the relationship through the event study approach. International Journal of Finance & Economics. https://doi.org/10.1002/ijfe.2484

[19] Behera, C., & Rath, B. N. (2021). The Covid-19 Pandemic And Indian Pharmaceutical Companies: An Event Study Analysis. Buletin Ekonomi Moneter Dan Perbankan, 24, 1–14. https://doi.org/ 10.21098/bemp.v24i0.1483

[20] Phuong, L. C. M. (2021). How COVID-19 impacts Vietnam's banking stocks: An event study method. Banks and Bank Systems, 16(1), 92-102.

[21] Yan, L., & Qian, Y. (2020). The Impact of COVID-19 on the Chinese Stock Market: An Event Study Based on the Consumer Industry. Asian Economics Letters. https://doi.org/10.46557/001c.18068

[22] Krivin, D., Patton, R., Rose, E., & Tabak, D. (2022). Determination of the Appropriate Event Window Length in Individual Stock Event Studies. Retrieved 7 July 2022.

[23] Thorbecke, W. (2022). Oil prices and the U.S. economy: Evidence from the stock market. Retrieved 12 June 2022.

[24] Aziz, D. (2022). The Russia-Ukraine Conflict and Its Implications for the Global Financial System. Retrieved 17 March 2022, from https://www.dallasfed.org/research/economics/2022/0517.aspx

[25] Javier, I., & Pedro, Á. (2022). Rising energy prices and their impact on the manufacturing industry: which sectors are being hit the hardest?. Retrieved 17 July 2022, from https://www. caixabankresearch.com/en/sector-analysis/industry/rising-energy-prices-and-their-impact-manufacturing-industry-which-sectors

[26] Phan, D., Tran, V., & Iyke, B. (2021). Geopolitical risk and bank stability. Financ. Res. Lett., 46, Article 102453

[27] Heilmann, K. (2016). Does political conflict hurt trade? Evidence from consumer boycotts. J. Int. Econ., 99, pp. 179-191

[28] Choudhry, T. (2010). World War II events and the Dow Jones industrial index. J. Bank. Financ., 34 (5), pp. 1022-1031

[29] Tosun, O., & Eshraghi, A. (2022). Corporate decisions in times of war: Evidence from the Russia-Ukraine conflict. Retrieved 17 July 2022.

[30] Antonakakis, N., Gupta, R. Kollias, C. Papadamou, S. (2017). Geopolitical risks and the oil-stock nexus over 1899–2016. Financ. Res. Lett., 23, pp. 165-173