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The Proximity Penalty by Sector: The Case of The War in Ukraine

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Abstract

This paper will analyze the impacts of geographical proximity to war on equity returns across sectors. Understanding the impacts of war on different sectors is crucial for portfolio management, and increased awareness about this topic can lead to better investment decisions. By using standard econometric techniques to capture the effects of distance on equity returns for different sectors, we find that in the case of the war in Ukraine, geographical proximity to conflict has the largest impact on the healthcare and technology sectors. We observe that across all countries, the healthcare sector performed 0.215 times worse, and the technology sector performed 0.315 times worse, relative to the benchmark.

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1. Introduction

As the conflict in Ukraine continues to affect global financial markets, the topic of rare economic disasters and their subsequent effects on equity returns remains a pertinent subject. A commonly accepted view is that stock markets react to changes in the perceived risk of wars and other similar rare disasters (Berkman et al., 2022; Gourio, 2012). Additionally, it has been proposed that the largest economic disasters involve international conflict, given the assumption that the conflict occurs on a country's own soil, (Barro, 2006). A recent development in the literature relating to this topic, Federle et al. (2022), attempts to analyze the relationship between disaster risk and equity returns while considering a country's geographical proximity to active combat. Federle et al. (2022) argues that the effects of warfare on financial markets are not limited to only those markets located in countries directly involved in the conflict. Instead, the possibility of regional escalation and military spillover creates risk in surrounding markets, and depending on the physical proximity to combat, this risk impacts countries differently. To quantify this risk, the paper identifies a "proximity penalty," and finds that countries and firms located closer to combat experienced more negative equity returns than countries located further from combat.

The purpose of this paper is to expand on Federle et al. (2022), and attempt to see if the identified proximity penalty impacts sectors differently. By adapting the model used in the original paper, with added variables for sector specification, we are able to see that the primary contributors to the proximity penalty were the healthcare and technology sectors, as these industries were the most negatively impacted by geographical distance to Ukraine. While it is difficult to determine whether these increasingly negative returns are a direct result of the war in Ukraine or a result of

externalities, the regressions used in this study help to better understand the impact that distance has on these sectors.

When turning to our results, we see that the added sector specifications complicate the original findings of Federle et al. (2022). By including variables for country and sector specific indices, the distance variable remains statistically significant, but shows a slight, yet still opposite effect of the proximity penalty. However, we are still able to gain insight on the effects of distance on equity returns by looking at both the country and sector variables. Because we use benchmarks to create these variables (the United States in the case of country variables and the energy sector in the case of sector variables), we can analyze the returns of countries located closer to Ukraine compared to the United States and see that these countries do experience significantly worse returns than the more distant benchmark. Additionally, we see that certain sectors within these countries do perform worse than others (relative to energy) during the event window. These insights we gain regarding the performance of different sectors allows for better investment decisions and enhanced risk mitigation strategies. A more detailed explanation of these results will be provided in the later results and discussion sections of this paper.

After reviewing the related literature on this topic, we will move to an overview of the data collection process and the methodology of the regressions. Next, we will turn to the results, and analyze the economic and statistical significance of the values we observe. Finally, we will discuss the implications and limitations of the study before concluding with the possibilities of future research relating to this idea.

2. Literature Review

The effects of war on financial markets is a widely studied topic. Much of the literature surrounding this idea focuses on the establishment of a risk premium in equity markets as a result of international conflict, a type of rare economic disaster. When disaster risk increases with war or the possibility of war, stock markets react accordingly with increasingly negative equity returns.

Federle et al. (2022), the primary paper that this study builds on, analyzes the relationship between the geographical proximity to war and equity returns. By measuring physical distances between Ukraine and 66 other countries, the researchers were able to see how equity returns were impacted differently based on distance. When looking at a four-week period surrounding the start of the war, the paper identified a proximity penalty and saw that the closer countries were to Ukraine, the worse their corresponding equity returns were. Additionally, this paper also found that within countries, the closer that individual firms were to Ukraine, the worse their returns were as well. The idea that war not only impacts the countries directly involved in the conflict, but also those in the surrounding area is important. Another interesting finding from this paper is that there was actually a "proximity premium" for defense stocks and the closer that firms in the defense industry were to Ukraine, the better their returns were. Because the defense industry is the only sector specification made by Federle et al. (2022), this thesis will provide key insight on how other sectors are impacted.

The Federle et al. (2022) paper itself draws upon many earlier studies that look into rare disasters and their connections to asset markets. Rietz (1988), Veronesi (2004), and Barro (2006) all attempt to offer solutions to asset-pricing puzzles and the equity-premium puzzle. Both Reitz (1988) and Veronesi (2004) expand on earlier models to explain the equity risk premium by

including the effects of rare disasters. Barro (2006) continues this research by analyzing the history of economic disasters during the twentieth century to determine the probabilities and implications of these disasters. This paper establishes that the most impactful economic disasters are related to international conflict. Both Berkman et al. (2011) and Gourio (2012) investigate the time-varying nature of economic disasters. Finally, to establish a model for the study, the Federle et al. (2022) paper utilizes a structural model from Fuchs-Schündeln and Hassan (2016), and Nakamura and Steinsson (2018). While these are just some of the studies that Federle et al. (2022) relies on, many of the unmentioned papers relate to similar aspects of market responses to rare disasters and conflict. Other papers have looked specifically into the Russia-Ukraine conflict, but what separates the Federle et al. (2022) paper is the focus on geographical proximity.

Because this paper will expand on the Federle et al. (2022) study by analyzing differences in sector, it is also important to review the literature surrounding this topic. Research on the impacts of war by sector is limited, with most literature relating to changes in commodity prices and their subsequent effects on stock prices. The majority of recent studies have focused on changes in oil prices, as most international conflicts in the past decades have related to energy disputes. Wolfers and Zitzewitz (2004) identifies a direct correlation between increases in the probability of war and increases in the spot oil price when looking at the war in Iraq. These types of changes in commodity prices often have the largest impact on the energy sector. For other sectors, the impacts of war are more difficult to delineate between. The motivations for war and the reasons for why nations choose to engage in combat, differ from conflict to conflict. Supply chain disruptions, tariffs, and other trade related restrictions all play a role in which industries are affected. In a general sense, travel and leisure stocks typically suffer. It makes logical sense that people are less likely to be engaged in tourism during wartime. Pandey and Kumar (2023) analyzes the impact of the Russia-

Ukraine war on global tourism. The paper's findings emulate those in Federle et al. (2022). Firms located in Europe, the Middle East, Africa, and the Pacific saw significantly negative abnormal returns, while the returns of those firms located in the Americas and Asia were insignificant. This difference provides indirect evidence for the existence of a proximity penalty for the tourism sector. War can also have a large impact on interest rates, causing financial stocks to suffer as investor concern rises. But because interest rates are influenced by a variety of causes, this idea is difficult to quantify in regard to conflict.

A gap in the literature exists when it comes to other sectors. The purpose of this paper is to fill this gap and provide evidence for how war impacts other sectors that are typically ignored in this framework. Based on our results, we see that the healthcare and technology sectors performed the worst during the observed time period. The lack of preexisting literature relating specifically to how these sectors react to war forces us to look to those more general ideas such as supply chain disruptions to offer potential explanations for the results we find.

3. Data Overview and Methodology

3.1 Data Overview

In order to quantify the effects of the proximity penalty across sectors, we analyze the daily price return data of sector specific indices for a set of countries with varying distances from Ukraine. This study utilizes the Refinitiv Country Sector Indices, available on the Thomson Reuters Datastream. To ensure that these indices capture a holistic representation of market fluctuations, total return indices are used as opposed to price return indices. The sectors included

are energy, financials, healthcare, industrials, materials, technology, and consumer non-cyclicals. Utilities are excluded from the study as a result of collinearity issues within the model. The Refinitiv Country Sector Indices vary for each country, with some countries having indices available for each of the seven sectors we analyze, and some countries only having indices for two. The number of sector indices available is dependent on the level of firm data that is accessible. The number of continuants for each index varies as well, with more developed economies typically having a higher number of firms within each index. The difference in the number of firms and sectors available for each country index creates slight interpretation issues for the model which will be explained in the results and discussion sections. A total of 163 sector indices are used in the sample. Table A1 of the appendix illustrates the sectorial breakdown by country.

For the initial regression, we use the daily prices of these indices, for the four-week period of February 10, 2022, through March 10, 2022, the same range that Federle et al. (2022) uses. February 24th is widely considered to be the "official" start date of the war between Russia and Ukraine, so this date is used as the center point for the study. The daily prices beginning two weeks prior to the 24th and two weeks after are what make up our data points. For additional regressions to ensure robustness, this time period will be changed, with the event window capturing a varying number of calendar days on either side of the February 24th center point.

Where Federle et al. (2022) analyzes broad country indices (national MSCI indices) to see how returns relate to geographical proximity, this paper will add to the literature by looking at this relationship across industries. The geographic distance between Kyiv and other countries' capitals will be measured in kilometers using the same technique as in Federle et al. (2022). The sample consists of 32 countries. This number was reached after eliminating countries that had less than

two sector specific indices available, and after excluding New Zealand for collinearity reasons. Russia and Ukraine are also excluded from the sample, as the purpose of this study is to focus on the effects on countries not directly involved in the war. The mean distance for all countries in the sample is 4,835 kilometers. The country with the largest distance from Ukraine is Chile (11,715 km) and the country with the smallest distance is Poland (27 km). A complete list of country distances is outlined in Table A2 of the appendix.

3.2 Methodology

3.2.1 Sector Model

For the primary model used in this study, we utilize a set of ordinary least squares (OLS) regressions. The equation below displays the form of these regressions:

$$\boldsymbol{CumRet_i^T = \beta_0 + \beta_1 DistanceUkraine_i + \beta_2 CountryControls_i} \\ \boldsymbol{+ \beta_3 SectorControls_i + \beta_4 (DistanceUkraine_i * Sector_i) + \varepsilon_i}$$

This general regression form was modified from Federle et al. (2022) to analyze the relationship between index returns across sectors and geographical proximity to war. In this regression, *i* serves to index countries and their subsequent distances from Ukraine and τ serves to index the event window in days relative to the start of the war. For the primary regression, $CumRet_i^\tau$ is used to measure cumulative stock market returns in logs within the 4-week period $\tau = [-14,14]$, centered around February 24, 2022. For additional robustness checks, cumulative returns in logs are still used, but the event window is modified to $\tau = [-1,7]$, $\tau = [-7,7]$, $\tau = [-1,14]$, $\tau = [-1,28]$, and $\tau = [-28,28]$. $DistanceUkraine_i$ denotes the distance between the specified country and Ukraine. To create dummy variables, the U.S. is used as a benchmark for

country variables, and energy is used as a benchmark for sector variables. These dummy variables are denoted by $CountryControls_i$ and $SectorControls_i$ respectively. The final variable, $(DistanceUkraine_i * Sector_i)$, describes the specific effects of distance on sector returns.

3.2.2 US Sector Model

To gain a better understanding of the results of the primary regression, a secondary regression is used to show the returns of U.S. sectors independent of other variables. The equation below displays the form of this regression:

$$\begin{aligned} \boldsymbol{CumRet_{US}^{\tau} = \beta_0 + \beta_1 Energy_{US} + \beta_2 Financials_{US} + \beta_3 Healthcare_{US}} \\ \boldsymbol{+ \beta_4 Industrials_{US} + \beta_5 Materials_{US} + \beta_6 Consumer_{US}} \\ \boldsymbol{+ \beta_7 Technology_{US} + \varepsilon_{US}} \end{aligned}$$

Here, $CumRet_{US}^{\tau}$ measures the cumulative returns in logs for all U.S. sectors, and the independent variables such as $Energy_{US}$ act as dummy variables which indicate the returns relating to a specific sector.

4. Results

While the purpose of this work is to adapt the original model to account for sector differences, these added sector variables create challenges regarding the statistical analysis of the distance variable. Standing alone, the distance variable suggests a negative correlation between equity returns and distance to Ukraine, with countries located further from Ukraine experiencing lower cumulative returns. Although this provides evidence against the existence of a proximity penalty, this could possibly be explained by the lower number of neighboring countries used in the

sample. However, when we look to the country specific variables, which account for distance, we see that on average, countries located closer to Ukraine experience increasingly negative returns. While the majority of the results shown in Table 1 are expected in regard to the country proximity penalty, the results relating to sector specifications offer key insights to how the proximity penalty impacts sectors differently. Overall, the model displays significant results with high R-squared values of 0.882, 0.897, and 0.900.

4.1 Sector Model for Baseline Period

TABLE 1

Effects of Distance on Sector Equity Returns

VARIABLES	(1) $CumRet_i^T$ Country	(2) $CumRet_i^T$ Sector	(3) $CumRet_i^T$ Distance*Sector
Distance	-5.69e-05***	-7.74e-05***	-7.00e-05***
	(1.26e-05)	(1.19e-05)	(1.86e-05)
Germany	-0.378***		
	(0.139)		
Italy	-1.147***		
	(0.156)		
Switzerland	-1.126***		
	(0.136)		
Finland	-0.147		
	(0.140)		
Turkey	-0.665***		
	(0.151)		
Poland	-2.545***		
	(0.153)		
Denmark	-1.659***		
	(0.155)		
Austria	-0.372**		
	(0.159)		
Financials		0.309***	
		(0.0466)	
Healthcare		-0.215***	
		(0.0539)	

Industrials		0.287***	
		(0.0476)	
Materials		0.683***	
		(0.0494)	
Consumer		0.452***	
		(0.0483)	
Technology		-0.315***	
		(0.0535)	
DEnergy			3.96e-05***
			(1.10e-05)
DFinancials			5.18e-05***
			(1.51e-05)
DHealthcare			5.31e-05***
			(1.87e-05)
DIndustrials			-1.24e-05
			(1.56e-05)
DMaterials			-3.53e-06
			(1.63e-05)
DConsumer			-5.27e-05***
			(1.55e-05)
DTechnology			3.64e-05**
			(1.85e-05)
Constant	6.768***	6.746***	6.579***
	(0.124)	(0.119)	(0.143)
Observations	3,759	3,759	3,759
R-squared	0.882	0.897	0.900

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

As the proximity penalty has already been identified, the results in column (1), apart from the distance coefficient, are expected. We obtain significant negative coefficients for almost all country variables, which indicate differences between the respective country and the reference country (United States). To provide an example, Switzerland's coefficient of -1.126 says that Switzerland's cumulative returns were 1.126 times lower than the United States' cumulative returns. Table 1 provides a condensed version of the full regression, including only the countries located within 1000 kilometers of Ukraine. The complete regression including all the country variables can be found in Table A3 of the appendix. When looking at the coefficients of these

countries specifically, we see that each of their returns are comparatively worse than the United States' returns. Poland, for example, is the closest country to Ukraine in our set, and its coefficient is -2.545, indicating that Poland's returns were 2.545 times worse than the United States' returns. These same results can be seen in the coefficients of the other countries included here, providing evidence for the existence of the proximity penalty. It is reasonable to assume that the possibility of regional escalation and military spillover in the area directly surrounding Ukraine would have the largest impact on the equity returns of the countries located closest to Ukraine, and this idea is supported by these country coefficients. The only insignificant variables are Australia and Finland (Australia's coefficient can be found in the appendix). Australia's positive coefficient suggests higher returns compared to the U.S., which might be explained by the significantly larger distance from Ukraine. An additional explanation could relate to trade flows and a lack of involvement with Russia and Ukraine. Although Finland's coefficient is negative, this value is insignificant.

Moving on to column (2), we again must keep in mind that a benchmark sector is used. For the purpose of this regression, we use energy as our reference sector. The coefficients of these variables indicate differences in returns between the respective sector and the energy sector. For example, the coefficient of -0.215 for healthcare indicates that across all countries, healthcare performed 0.215 times worse than energy. All sector coefficients are significant. We see that both healthcare and technology performed worse than energy, while financials, industrials, materials, and consumer all performed better than energy. It is important to note that the positive coefficients for financials, industrials, materials, and consumer do not suggest that these industries saw positive returns during this period, only that their returns were less negative compared to the benchmark. However, to see the true effects of distance on these sectors, we must turn to a sensitivity analysis.

Finally, column (3) illustrates the sensitivity of these sectors to distance. The interaction variables, "Distance*Sector," allow us to test whether the relationship between distance and returns differs depending on the sector. The negative coefficients indicate less sensitivity to distance while the positive coefficients indicate more sensitivity, in comparison to energy. These results offer similar insights as those in column (2). Healthcare and technology indicate high levels of sensitivity. An initial explanation for this observed sensitivity is that the supply chain disruptions and trade restrictions that resulted from the war were more closely related to these two industries compared to other industries. In addition, financials also show a high level of sensitivity. The sensitivity observed regarding the financial industry is more difficult to interpret, as interest rates and inflation expectations heavily influence the performance of stocks in this sector and changes in these drivers may not be solely related to the war. All coefficients besides industrials and materials are statistically significant.

4.2 Sector Model with Varying Time Series

To check for robustness, we modify the final regression form shown in column (3) of Table 1 to account for varying event windows.

TABLE 2

Effects of Distance on Sector Equity Returns with Event Window Variations

	$\tau = [-1,7]$	$\tau = [-7,7]$	$\tau = [-1,14]$	$\tau = [-1,28]$	$\tau = [-28,28]$
	(1)	(2)	(3)	(4)	(5)
VARIABLES	$CumRet_i^T$	$CumRet_i^T$	$CumRet_i^T$	$CumRet_i^T$	$CumRet_i^T$
Distance	-7.09e-05**	-6.92e-05***	-7.26e-05***	-7.27e-05***	-6.92e-05***
	(3.26e-05)	(2.58e-05)	(2.48e-05)	(1.83e-05)	(1.33e-05)
Germany	-0.450*	-0.421**	-0.483***	-0.484***	-0.429***
	(0.232)	(0.183)	(0.176)	(0.130)	(0.0945)
Italy	-1.159***	-1.133***	-1.202***	-1.218***	-1.159***
	(0.261)	(0.206)	(0.198)	(0.146)	(0.106)

Switzerland	-1.178***	-1.169***	-1.199***	-1.205***	-1.182***
	(0.226)	(0.179)	(0.172)	(0.127)	(0.0921)
Finland	-0.325	-0.303*	-0.357**	-0.352***	-0.306***
	(0.232)	(0.184)	(0.177)	(0.130)	(0.0947)
Turkey	-1.054***	-1.027***	-1.051***	-1.049***	-1.020***
	(0.250)	(0.198)	(0.191)	(0.140)	(0.102)
Poland	-2.932***	-2.895***	-2.965***	-2.959***	-2.900***
	(0.254)	(0.201)	(0.193)	(0.142)	(0.104)
Denmark	-1.571***	-1.557***	-1.587***	-1.576***	-1.552***
	(0.258)	(0.204)	(0.196)	(0.145)	(0.105)
Austria	-0.684***	-0.637***	-0.719***	-0.725***	-0.639***
	(0.264)	(0.209)	(0.201)	(0.148)	(0.108)
Financials	0.138	0.165	0.103	0.110	0.166**
	(0.161)	(0.127)	(0.123)	(0.0902)	(0.0656)
Healthcare	-0.359*	-0.361**	-0.364**	-0.355***	-0.353***
	(0.190)	(0.150)	(0.145)	(0.107)	(0.0775)
Industrials	0.422***	0.433***	0.407***	0.415***	0.437***
	(0.163)	(0.129)	(0.124)	(0.0915)	(0.0666)
Materials	0.800***	0.806***	0.782***	0.785***	0.798***
	(0.176)	(0.139)	(0.134)	(0.0984)	(0.0716)
Consumer	0.818***	0.830***	0.795***	0.797***	0.829***
	(0.169)	(0.134)	(0.129)	(0.0948)	(0.0690)
Technology	-0.382**	-0.375**	-0.399***	-0.399***	-0.370***
	(0.187)	(0.148)	(0.142)	(0.105)	(0.0761)
DEnergy	3.92e-05**	3.81e-05**	4.15e-05***	4.18e-05***	3.88e-05***
	(1.93e-05)	(1.52e-05)	(1.47e-05)	(1.08e-05)	(7.85e-06)
DFinancials	5.32e-05**	5.10e-05**	5.60e-05***	5.60e-05***	5.04e-05***
	(2.65e-05)	(2.10e-05)	(2.02e-05)	(1.48e-05)	(1.08e-05)
DHealthcare	5.34e-05	5.39e-05**	5.28e-05**	5.17e-05***	5.25e-05***
	(3.29e-05)	(2.60e-05)	(2.50e-05)	(1.84e-05)	(1.34e-05)
DIndustrials	-1.21e-05	-1.28e-05	-1.09e-05	-1.14e-05	-1.37e-05
	(2.74e-05)	(2.16e-05)	(2.08e-05)	(1.53e-05)	(1.11e-05)
DMaterials	-4.34e-06	-5.76e-06	-5.59e-07	-1.09e-06	-5.24e-06
	(2.85e-05)	(2.25e-05)	(2.17e-05)	(1.60e-05)	(1.16e-05)
DConsumer	-5.14e-05*	-5.27e-05**	-4.99e-05**	-5.10e-05***	-5.45e-05***
	(2.71e-05)	(2.15e-05)	(2.07e-05)	(1.52e-05)	(1.11e-05)
DTechnology	3.61e-05	3.60e-05	3.65e-05	3.64e-05**	3.55e-05***
	(3.25e-05)	(2.57e-05)	(2.47e-05)	(1.82e-05)	(1.32e-05)
Constant	6.585***	6.570***	6.600***	6.611***	6.584***
	(0.251)	(0.198)	(0.191)	(0.141)	(0.102)
Observations	1,253	1,969	2,148	3,938	7,339
R-squared	0.900	0.901	0.899	0.899	0.900

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

When we adjust for different event windows, we observe similar results as in our initial regression. Our R-squared values remain high, and the majority of the variable coefficients remain significant. This additional robustness check allows us to ensure that the observed results of the initial regression are not skewed by differences in returns between dates. Additionally, we are able to see that the proximity penalty extends beyond the baseline two-week event window. This illustrates that the effects of war on equity returns may originate earlier and may persist for longer than expected. Like Table 1, Table 2 provides a condensed version of the full regression. Table A4 of the appendix provides the complete version.

4.3 US Sector Model

Because we use the United States as a benchmark for the country variables, analyzing the country's returns independently of other variables provides useful insight for the interpretation of the proximity penalty. Looking across all industries, we see that each of the United States' sectors saw negative returns during the event window. The fact that other countries' returns were still comparatively worse during this same period suggests further evidence for the idea that proximity to war has a significant impact on equity returns. This regression illustrates that the negative coefficients observed for other country variables are not simply the result of a significantly better performing benchmark. If these variables for the U.S. were instead positive, the negative coefficients observed in column (1) of the initial regression could indicate lesser positive returns as opposed to actual negative returns.

TABLE 3

United States Sector Breakdown

VARIABLES	(1) $CumRet_i^T$
Energy	-0.662***
	(0.00950)
Financials	-0.698***
	(0.00950)
Healthcare	-0.291***
	(0.00950)
Industrials	-0.306***
	(0.00950)
Materials	-0.178***
	(0.00950)
Consumer	-0.367***
	(0.00950)
Technology	-0.264***
	(0.00950)
Constant	6.759***
	(0.00672)
Observations	168
R-squared	0.981

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

Looking at the differences between industries in the U.S. can grant us a better understanding of the effects of distance on specific sectors for other countries. Where column (2) of our initial regression suggests that healthcare and technology performed the worst across all countries, we see here that in the U.S. these sectors were not the worst performing. Instead, the energy, financials, and consumer sectors saw the most negative returns, with significant coefficients of -0.662, -0.698, and -0.367 respectively. This allows us to verify that the role of distance in influencing the returns of these sectors in other countries is in fact significant.

5. Discussion and Limitations

The sector specifications of the model used in this study create challenges when it comes to the interpretation of the proximity penalty. In order to replicate the findings of Federle et al. (2022), the same countries needed to be used in our sample. However, because we required country specific sector indices to differentiate the effects of the proximity penalty across industries, we had to eliminate a large amount of the countries used in Federle et al. (2022) because they did not have sector indices readily available. Additionally, for consistency purposes, it was necessary to use the same index provider for all indices used, as different providers use different methods in constructing their indices. This narrowed our options when it came to selection, and forced our hand into using the Refinitiv Country Sector Indices, the platform that provided the largest number of country specific sector indices. Where Federle et al. (2022) was able to include a larger number of countries, with more variable distances to Ukraine, because of the broad MSCI country indices used, our data set was limited to a much smaller number of countries. Because of differences in firm data available between countries, a large number of neighboring countries to Ukraine were eliminated, causing the proximity penalty to become less prominent. The mean distance of our data set is 4,835 kilometers whereas the mean distance of Federle et al. (2022) is 3,959 kilometers.

This difference in distances between the countries used in our set causes the distance variable to suggest the opposite effect of the proximity penalty. However, we are still able to gain valuable information by looking at the individual country variables and comparing them to the United States. Moreover, the sector variables provide insight to how the proximity penalty differs across sectors. The observed values relating to healthcare and technology are worthy of further

investigation. Why these sectors would perform significantly worse than energy during wartime is difficult to determine.

A possible explanation could relate to specific impacts of the war on supply chains. The healthcare industry is dependent on the supply of medical equipment and other products needed to treat patients. Any disruption to this supply will cause firms within the industry to suffer. In a more general sense, the violent nature of war puts extreme levels of pressure on hospitals and other healthcare providers in the area. The possibility of military escalation within the region may cause staff to flee, leaving hospitals limited in their ability to provide care. For technology, a more specific supply chain disruption can be pointed to. Ukraine is one of the largest providers of high-grade neon gas, which is a primary component in the production of semiconductor chips. Additionally, Russia is a major supplier of palladium, a key metal used in the production of catalytic converters. The war has caused the supply of these two raw materials to be reduced by a large amount. Neon suppliers in Ukraine were forced to halt production following the invasion, and many countries placed trade restrictions on Russia, reducing the global supply of palladium. The reduction of this supply makes it difficult for technology firms to continue to produce at high levels because of their reliance on these materials.

Looking at the sensitivity analysis, the sensitivity we observe in the financial industry may have a relatively simple explanation: interest rates. As interest rates are bound by inflation expectations, it makes sense that during a time of war these rates would be extremely volatile. Volatility in interest rates has a significant impact on the financial industry. Investors become increasingly hesitant to use financial services during periods of high volatility.

It is important to acknowledge that these are just a few of the possible explanations for the results we see in relation to these industries. The effects of war are difficult to differentiate between because they often impact all aspects of the economy. We must also keep in mind the benchmarks used. Because the performance of different sectors is relative to energy, the impacts of the war on the energy sector must also be acknowledged. A major impact of the war was an increase in the spot prices of oil. While this increase in price could benefit energy companies by allowing for larger margins, it is more likely that the decrease in demand would outweigh the benefits resulting from the price increase. The fact that the healthcare and technology sectors still performed worse than energy, in a time when the energy sector was experiencing significant losses, makes these findings even more interesting.

A final consideration should be made regarding the chosen event window. Because some sectors may have reacted to the news of the war earlier than others, the performance of their corresponding indices may have been impacted at different times. In response to this, we take a conservative approach, and assume that the news of the war was first a surprise, and second, was received by all sectors at the same time.

6. Conclusion

Despite the limitations discussed above, the models utilized in this study indicate that the effects of the proximity penalty differ from sector to sector. Depending on the industry, geographical proximity to war can either be beneficial or detrimental to returns. This idea has many implications when it comes to risk mitigation and portfolio management. Investors can utilize the knowledge gained from this study to insulate themselves from the negative effects of

war. Because sectors react differently, a mitigation strategy could possibly result in increased diversification across both countries and sectors. In a time of geopolitical uncertainty, understanding the impacts of international conflict on different sectors can allow investors to make educated decisions regarding their portfolios. In future situations, when war is either expected or imminent, investors can stay ahead of the curve and reweight their portfolios in ways to mitigate the effects of disaster risk.

Still, further research is necessary to solidify these findings. The lack of sector indices available for the countries surrounding Ukraine makes it difficult to rely on the results of the model. Future studies conducted by researchers with better access to data could improve the models used here by including a larger number of countries, with more variable distances. Additionally, different sector specifications could be used to see the effects on more niche industries.

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8. Appendix

TABLE A1

Sectorial Breakdown by Country

Country	Energy	Financials	Healthcare	Industrials	Materials	Consumer	Technology	Totals
Australia	1	1	1	1	1	1	1	7
Austria	0	1	0	1	1	0	0	3
Belgium	0	1	1	1	1	1	0	5
Brazil	0	1	0	1	1	1	0	4
Canada	1	1	1	1	1	1	1	7
Chile	0	1	0	0	1	1	0	3
Denmark	0	1	1	1	0	0	0	3
Finland	0	1	0	1	1	1	1	5
France	0	1	1	1	1	1	1	6
Germany	0	1	1	1	1	1	1	6
Hong Kong	1	1	1	1	1	1	1	7
India	1	1	1	1	1	1	1	7
Israel	1	1	1	1	0	1	1	6
Italy	0	1	0	1	0	0	0	2
Japan	1	1	1	1	1	1	1	7
Korea	1	1	1	1	1	1	1	7
Malaysia	1	1	1	1	1	1	1	7
Mexico	0	1	0	1	1	1	0	4
Netherlands	0	1	0	1	0	1	0	3
Norway	1	1	0	1	0	1	1	5
Pakistan	1	1	0	0	1	0	0	3
Philipines	0	1	0	1	1	1	0	4
Poland	0	1	0	1	1	1	0	4
Singapore	0	1	1	1	0	1	1	5
South Africa	0	1	0	1	1	1	0	4
Spain	0	1	0	1	0	0	0	2
Switzerland	0	1	1	1	1	1	1	6
Taiwan	0	1	1	1	1	1	1	6
Thailand	1	1	1	1	1	1	1	7
Turkey	0	1	0	1	1	1	0	4
UK	1	1	1	1	1	1	1	7
US	1	1	1	1	1	1	1	7
Totals	13	32	18	30	25	27	18	163

TABLE A2

Distances of Countries from Ukraine

Country	Distance
Australia	10723
Austria	390
Belgium	1175
Brazil	8161
Canada	5155
Chile	11715
Denmark	881
Finland	909
France	1045
Germany	589
Hong Kong	7045
India	3233
Israel	1249
Italy	704
Japan	7086
Korea	6751
Malaysia	7316
Mexico	9507
Netherlands	1151
Norway	1154
Pakistan	2955
Philipines	7759
Poland	27
Singapore	8012
South Africa	7436
Spain	1631
Switzerland	941
Taiwan	7162
Thailand	6086
Turkey	279
UK	1506
US	6245

TABLE A3

Effects of Distance on Sector Equity Returns

VARIABLES	(1) $CumRet_i^T$ Country	(2) $CumRet_i^T$ Sector	(3) $CumRet_i^T$ Distance*Sector
Distance	-5.69e-05***	-7.74e-05***	-7.00e-05***
	(1.26e-05)	(1.19e-05)	(1.86e-05)
Canada	-0.511***	-0.533***	-0.510***
	(0.0962)	(0.0900)	(0.0888)
UK	-0.712***	-0.809***	-0.708***
	(0.125)	(0.117)	(0.119)
Japan	-5.777***	-5.760***	-5.778***
	(0.0869)	(0.0814)	(0.0802)
Hong Kong	-2.162***	-2.145***	-2.162***
	(0.0870)	(0.0815)	(0.0803)
India	-2.876***	-2.937***	-2.873***
	(0.110)	(0.103)	(0.103)
Malaysia	-1.391***	-1.369***	-1.392***
	(0.0862)	(0.0807)	(0.0796)
Korea	-7.535***	-7.525***	-7.536***
	(0.0881)	(0.0825)	(0.0812)
Thailand	-3.629***	-3.632***	-3.629***
	(0.0910)	(0.0852)	(0.0838)
Australia	0.141	0.212**	0.0897
	(0.0902)	(0.0847)	(0.0874)
Germany	-0.378***	-0.544***	-0.433***
	(0.139)	(0.131)	(0.132)
France	-0.652***	-0.809***	-0.707***
	(0.135)	(0.127)	(0.128)
Italy	-1.147***	-1.309***	-1.153***
	(0.156)	(0.148)	(0.149)
Belgium	-0.797***	-1.054***	-0.970***
	(0.137)	(0.130)	(0.130)
Brazil	-0.690***	-0.846***	-0.807***
	(0.0978)	(0.0918)	(0.0911)
Israel	-1.985***	-2.023***	-1.915***
	(0.133)	(0.125)	(0.126)
Switzerland	-1.126***	-1.285***	-1.181***
	(0.136)	(0.128)	(0.129)
Finland	-0.147	-0.389***	-0.315**
	(0.140)	(0.132)	(0.132)

Norway	-2.321***	-2.422***	-2.337***
	(0.138)	(0.130)	(0.130)
Turkey	-0.665***	-1.070***	-1.022***
	(0.151)	(0.143)	(0.143)
Poland	-2.545***	-2.956***	-2.907***
	(0.153)	(0.146)	(0.145)
Denmark	-1.659***	-1.746***	-1.562***
	(0.155)	(0.147)	(0.147)
Austria	-0.372**	-0.768***	-0.643***
	(0.159)	(0.151)	(0.151)
Singapore	-0.651***	-0.569***	-0.614***
	(0.0980)	(0.0923)	(0.0914)
Mexico	-3.036***	-3.252***	-3.234***
	(0.106)	(0.0994)	(0.0984)
South Africa	3.241***	2.983***	3.008***
	(0.107)	(0.101)	(0.0995)
Netherlands	-0.923***	-1.227***	-1.184***
	(0.153)	(0.145)	(0.143)
Spain	-1.000***	-1.242***	-1.114***
	(0.166)	(0.158)	(0.156)
Philippines	-4.722***	-4.887***	-4.845***
	(0.0984)	(0.0924)	(0.0916)
Pakistan	-3.840***	-4.088***	-4.017***
	(0.139)	(0.131)	(0.131)
Chile	-6.624***	-6.723***	-6.712***
	(0.111)	(0.105)	(0.109)
Taiwan	-3.781***	-3.812***	-3.829***
	(0.0942)	(0.0886)	(0.0873)
Financials		0.309***	0.157*
		(0.0466)	(0.0918)
Healthcare		-0.215***	-0.360***
		(0.0539)	(0.108)
Industrials		0.287***	0.429***
		(0.0476)	(0.0932)
Materials		0.683***	0.796***
		(0.0494)	(0.100)
Consumer		0.452***	0.823***
		(0.0483)	(0.0965)
Technology		-0.315***	-0.377***
		(0.0535)	(0.107)
DEnergy			3.96e-05***
			(1.10e-05)
DFinancials			5.18e-05***
			(1.51e-05)
DHealthcare			5.31e-05***

			(1.87e-05)
DIndustrials			-1.24e-05
			(1.56e-05)
DMaterials			-3.53e-06
			(1.63e-05)
DConsumer			-5.27e-05***
			(1.55e-05)
DTechnology			3.64e-05**
			(1.85e-05)
Constant	6.768***	6.746***	6.579***
	(0.124)	(0.119)	(0.143)
Observations	3,759	3,759	3,759
R-squared	0.882	0.897	0.900

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

TABLE A4

Effects of Distance on Sector Equity Returns with Event Window Variations

	$\tau = [-1,7]$	$\tau = [-7,7]$	$\tau = [-1,14]$	$\tau = [-1,28]$	$\tau = [-28,28]$
	(1)	(2)	(3)	(4)	(5)
VARIABLES	$CumRet_i^T$	$CumRet_i^T$	$CumRet_i^T$	$CumRet_i^T$	$CumRet_i^T$
Distance	-7.09e-05**	-6.92e-05***	-7.26e-05***	-7.27e-05***	-6.92e-05***
	(3.26e-05)	(2.58e-05)	(2.48e-05)	(1.83e-05)	(1.33e-05)
Canada	-0.516***	-0.515***	-0.510***	-0.506***	-0.511***
	(0.156)	(0.123)	(0.119)	(0.0872)	(0.0635)
UK	-0.707***	-0.694***	-0.731***	-0.740***	-0.715***
	(0.209)	(0.165)	(0.159)	(0.117)	(0.0850)
Japan	-5.774***	-5.770***	-5.787***	-5.803***	-5.791***
	(0.141)	(0.111)	(0.107)	(0.0788)	(0.0573)
Hong Kong	-2.160***	-2.146***	-2.187***	-2.232***	-2.194***
	(0.141)	(0.111)	(0.107)	(0.0789)	(0.0574)
India	-2.881***	-2.864***	-2.894***	-2.893***	-2.869***
	(0.181)	(0.143)	(0.138)	(0.101)	(0.0736)
Malaysia	-1.386***	-1.383***	-1.397***	-1.411***	-1.408***
	(0.140)	(0.110)	(0.106)	(0.0782)	(0.0569)
Korea	-7.528***	-7.527***	-7.535***	-7.545***	-7.551***
	(0.142)	(0.113)	(0.108)	(0.0797)	(0.0580)
Thailand	-3.621***	-3.613***	-3.639***	-3.656***	-3.650***
	(0.147)	(0.116)	(0.112)	(0.0823)	(0.0599)
Australia	0.0969	0.0911	0.105	0.114	0.0848
	(0.153)	(0.121)	(0.117)	(0.0858)	(0.0624)
Germany	-0.450*	-0.421**	-0.483***	-0.484***	-0.429***
	(0.232)	(0.183)	(0.176)	(0.130)	(0.0945)
France	-0.711***	-0.692***	-0.740***	-0.744***	-0.706***
	(0.224)	(0.177)	(0.171)	(0.126)	(0.0914)
Italy	-1.159***	-1.133***	-1.202***	-1.218***	-1.159***
	(0.261)	(0.206)	(0.198)	(0.146)	(0.106)
Belgium	-0.968***	-0.953***	-1.000***	-1.000***	-0.970***
	(0.228)	(0.180)	(0.174)	(0.128)	(0.0930)
Brazil	-0.802***	-0.805***	-0.798***	-0.789***	-0.812***
	(0.160)	(0.126)	(0.122)	(0.0895)	(0.0651)
Israel	-1.912***	-1.903***	-1.925***	-1.936***	-1.923***
	(0.221)	(0.175)	(0.168)	(0.124)	(0.0900)
Switzerland	-1.178***	-1.169***	-1.199***	-1.205***	-1.182***
	(0.226)	(0.179)	(0.172)	(0.127)	(0.0921)
Finland	-0.325	-0.303*	-0.357**	-0.352***	-0.306***
	(0.232)	(0.184)	(0.177)	(0.130)	(0.0947)
Norway	-2.330***	-2.330***	-2.341***	-2.336***	-2.336***
	(0.228)	(0.181)	(0.174)	(0.128)	(0.0931)

Turkey	-1.054***	-1.027***	-1.051***	-1.049***	-1.020***
	(0.250)	(0.198)	(0.191)	(0.140)	(0.102)
Poland	-2.932***	-2.895***	-2.965***	-2.959***	-2.900***
	(0.254)	(0.201)	(0.193)	(0.142)	(0.104)
Denmark	-1.571***	-1.557***	-1.587***	-1.576***	-1.552***
	(0.258)	(0.204)	(0.196)	(0.145)	(0.105)
Austria	-0.684***	-0.637***	-0.719***	-0.725***	-0.639***
	(0.264)	(0.209)	(0.201)	(0.148)	(0.108)
Singapore	-0.620***	-0.610***	-0.621***	-0.625***	-0.626***
	(0.160)	(0.127)	(0.122)	(0.0897)	(0.0653)
Mexico	-3.225***	-3.223***	-3.239***	-3.232***	-3.241***
	(0.173)	(0.136)	(0.131)	(0.0967)	(0.0703)
South Africa	3.014***	3.020***	3.003***	3.006***	2.997***
	(0.174)	(0.138)	(0.133)	(0.0977)	(0.0711)
Netherlands	-1.191***	-1.171***	-1.219***	-1.230***	-1.185***
	(0.251)	(0.199)	(0.191)	(0.141)	(0.102)
Spain	-1.123***	-1.101***	-1.151***	-1.149***	-1.118***
	(0.274)	(0.217)	(0.208)	(0.153)	(0.112)
Philippines	-4.838***	-4.838***	-4.842***	-4.867***	-4.862***
	(0.161)	(0.127)	(0.122)	(0.0899)	(0.0654)
Pakistan	-4.020***	-4.009***	-4.032***	-4.063***	-4.032***
	(0.230)	(0.181)	(0.175)	(0.129)	(0.0935)
Chile	-6.723***	-6.719***	-6.716***	-6.700***	-6.711***
	(0.191)	(0.151)	(0.145)	(0.107)	(0.0777)
Taiwan	-3.820***	-3.818***	-3.830***	-3.846***	-3.848***
	(0.153)	(0.121)	(0.117)	(0.0857)	(0.0624)
Financials	0.138	0.165	0.103	0.110	0.166**
	(0.161)	(0.127)	(0.123)	(0.0902)	(0.0656)
Healthcare	-0.359*	-0.361**	-0.364**	-0.355***	-0.353***
	(0.190)	(0.150)	(0.145)	(0.107)	(0.0775)
Industrials	0.422***	0.433***	0.407***	0.415***	0.437***
	(0.163)	(0.129)	(0.124)	(0.0915)	(0.0666)
Materials	0.800***	0.806***	0.782***	0.785***	0.798***
	(0.176)	(0.139)	(0.134)	(0.0984)	(0.0716)
Consumer	0.818***	0.830***	0.795***	0.797***	0.829***
	(0.169)	(0.134)	(0.129)	(0.0948)	(0.0690)
Technology	-0.382**	-0.375**	-0.399***	-0.399***	-0.370***
	(0.187)	(0.148)	(0.142)	(0.105)	(0.0761)
DEnergy	3.92e-05**	3.81e-05**	4.15e-05***	4.18e-05***	3.88e-05***
	(1.93e-05)	(1.52e-05)	(1.47e-05)	(1.08e-05)	(7.85e-06)
DFinancials	5.32e-05**	5.10e-05**	5.60e-05***	5.60e-05***	5.04e-05***
	(2.65e-05)	(2.10e-05)	(2.02e-05)	(1.48e-05)	(1.08e-05)
DHealthcare	5.34e-05	5.39e-05**	5.28e-05**	5.17e-05***	5.25e-05***
	(3.29e-05)	(2.60e-05)	(2.50e-05)	(1.84e-05)	(1.34e-05)
DIndustrials	-1.21e-05	-1.28e-05	-1.09e-05	-1.14e-05	-1.37e-05

	(2.74e-05)	(2.16e-05)	(2.08e-05)	(1.53e-05)	(1.11e-05)
DMaterials	-4.34e-06	-5.76e-06	-5.59e-07	-1.09e-06	-5.24e-06
	(2.85e-05)	(2.25e-05)	(2.17e-05)	(1.60e-05)	(1.16e-05)
DConsumer	-5.14e-05*	-5.27e-05**	-4.99e-05**	-5.10e-05***	-5.45e-05***
	(2.71e-05)	(2.15e-05)	(2.07e-05)	(1.52e-05)	(1.11e-05)
DTechnology	3.61e-05	3.60e-05	3.65e-05	3.64e-05**	3.55e-05***
	(3.25e-05)	(2.57e-05)	(2.47e-05)	(1.82e-05)	(1.32e-05)
Constant	6.585***	6.570***	6.600***	6.611***	6.584***
	(0.251)	(0.198)	(0.191)	(0.141)	(0.102)
Observations	1,253	1,969	2,148	3,938	7,339
R-squared	0.900	0.901	0.899	0.899	0.900

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