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Incorporating a Geopolitical Risk Index in momentum investment strategies

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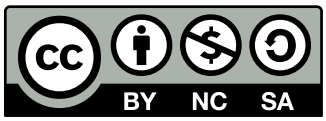

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Abstract

In the dynamic landscape of global financial markets, the pursuit of robust investment strategies is a continuous challenge. Tackling the challenge of geopolitical risk has gained increasing attention from investors as a key determinant of investment decisions.

This thesis aims to construct momentum investment strategies based on the Geopolitical Risk Index, utilizing the assumption of a negative correlation between geopolitical risk and investment returns. The investment strategies are constructed individually for six countries and each strategy uses past changes in the geopolitical tension in a specific country to decide monthly investment decisions to the main equity index of the country in question. Increasing geopolitical risk triggers the strategy to short the main equity index while decreasing, stable, or not significantly increasing geopolitical risk triggers the strategy to buy the main equity index. These strategies are constructed to maximize the Sharpe ratio with different sensitivities to increases in geopolitical risk as well as different reaction times that trigger the monthly investment decisions. The primary objectives of this thesis are thus to assess the relationship between geopolitical risk and investment returns; and to construct investment strategies that help protect investments against geopolitical crises by anticipating future returns due to changes in geopolitical risk.

The assumption of a negative correlation between geopolitical risk and investment returns is validated through a literature review and data analysis. The results of the thesis show that all six strategies constructed outperform the equity indices according to the Sharpe ratio, and most of the time, the strategies predict future movements of the equity indices correctly. Therefore, the results indicate that geopolitical risk has predictive power for future investment returns, and thus it can be used to hedge against the effects of geopolitical tensions on financial markets. Through explorative analysis, the thesis also discusses the complex nature of the relationship between geopolitical risk and investment returns. The analysis suggests that future development of the strategies could improve their performance by including more variables in the decision-making algorithm.

Keywords geopolitical risk, momentum investing, hedging, investment strategy

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Tiivistelmä

Rahoitusmarkkinoiden dynaamisessa maailmassa robustisten sijoitusstrategioiden tavoittelu on jatkuva haaste. Tähän haasteeseen vastaamisessa geopoliittinen riski on saanut yhä enemmän huomiota sijoittajilta keskeisenä sijoituspäätöksiä ohjaavana tekijänä.

Tämän diplomityön tavoitteena on rakentaa momentum-sijoitusstrategioita geopoliittisen riskin pohjalta hyödyntäen geopoliittisen riskin ja sijoitustuottojen välistä negatiivista korrelaatiota. Sijoitusstrategiat laaditaan erikseen kuudelle maalle, ja jokainen strategia hyödyntää kyseisen maan geopoliittisen jännitteen aikaisempia muutoksia kuukausittaisten sijoituspäätösten tekemiseen kyseisen maan pääosakeindeksiin. Kasvava geopoliittinen riski aiheuttaa pääosakeindeksin lyhyeksi myymisen, kun taas laskeva, vakaa tai ei merkittävästi kasvava geopoliittinen riski aiheuttaa pääosakeindeksin ostamisen. Nämä strategiat maksimoivat Sharpen lukua optimoimalla herkkyyden geopoliittisen riskin kasvulle sekä reaktioajan, jotka määrittävät kuukausittaiset sijoituspäätökset. Tämän opinnäytetyön ensisijaisena tavoitteena on arvioida geopoliittisen riskin ja sijoitustuottojen välistä suhdetta sekä rakentaa sijoitusstrategioita, joilla voidaan ennakoida geopoliittisen riskin vaihtelusta aiheutuvia sijoitustuottojen muutoksia.

Oletus negatiivisesta korrelaatiosta geopoliittisen riskin ja sijoitustuottojen välillä vahvistetaan kirjallisuuskatsauksen ja data-analyysin avulla. Työn tulokset osoittavat, että kaikki kuusi rakennettua strategiaa suoriutuvat paremmin kuin pääosakeindeksit Sharpen luvun valossa ja strategiat ennustavat pääosakeindeksien tulevaisuuden liikkeitä oikein suurimman osan tutkitusta ajasta. Näin ollen tulokset osoittavat, että geopoliittisella riskillä pystytään ennakoimaan sijoitustuottoja, ja näin ollen sitä voidaan käyttää suojautumiseen rahoitusmarkkinoiden geopoliittisten jännitteiden vaikutuksilta. Tarkemman analyysin avulla työ valottaa geopoliittisen riskin ja sijoitustuottojen välisen suhteen monimutkaista luonnetta. Sitä voidaan käyttää strategioiden kehittämisessä siten, että päätöksentekoon sisällytetään enemmän muuttujia, mikä voisi parantaa strategioiden tuloksellisuutta kuvaavia tunnuslukuja entisestään.

Avainsanat geopoliittinen riski, momentum-sijoittaminen, riskeiltä suojautuminen sijoittamisessa, sijoitusstrategia

Preface

I want to thank Professor Ahti Salo for their support and guidance during this thesis. Additionally, I want to thank my partner, friends, and family for supporting me throughout my studies and in everyday life.

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Abbreviations

Abbreviations

GPR	Geopolitical Risk
CHN	China
DEU	Germany
FRA	France
JPN	Japan
RUS	Russia
USA	The United States

1 Introduction

In the dynamic landscape of global financial markets, the pursuit of robust investment strategies is an ever-evolving challenge. The 2020's have experienced an increased frequency of negative geopolitical events, such as the ongoing Russia-Ukraine conflict and the COVID-19 pandemic. Therefore, as investors navigate amidst market forces, one variable that has gained increasing recognition is geopolitical risk as market participants, central bank officials and entrepreneurs regard geopolitical risk as a key determinant of investment decisions (Caldara and Iacoviello, 2022). Geopolitical events and uncertainties have the potential to significantly impact financial markets, influencing investor behavior (He, 2023) and the returns of investments (Agoraki et al., 2022). This thesis seeks to explore and enhance the efficacy of momentum investment strategies by using a Geopolitical Risk Index (Caldara and Iacoviello, 2022) as the fundamental variable.

In general, investors hedge their investments by diversifying their portfolios. During significant geopolitical crises, most asset classes decline, and therefore a diverse portfolio is not adequate to protect the value of investments (Hasan et al., 2021). Therefore, in previous studies, the use of safe-haven assets has been used to protect investments from geopolitical risks (Hasan et al., 2021). Safe-haven is defined by Baur and Lucey (2010) as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market turmoil. In general, precious metals, government bonds, currencies, and alternative assets are seen as traditional safe-haven assets (Kopyl and Lee, 2016). However, there is a weakness in using safe-haven assets to protect investments against geopolitical risks. An analysis done by Kopyl and Lee (2016) demonstrated that during significant market turmoil, some of the strongest safe-haven assets lose their safe-haven status. Additionally, identifying adequate safe-haven assets with the data available before the different crises is difficult. In light of this evidence, safe-haven assets are not guaranteed to keep their safe-haven properties, and these assets are often identifiable only ex-post. This could suggest using alternative measures for investors to protect their portfolios against geopolitical risks, which could be argued to be exogenous in nature.

In this thesis, momentum investment strategies based on the Geopolitical Risk Index are constructed. Contrary to the traditional methods, e.g., diversification and investing in safe-haven assets — which often do not have a view on which investments are expected to decrease in value — this methodology tries to determine whether the effects of these crises could be mitigated by using an active investment strategy. The traditional paradigm of momentum investing revolves around the idea that assets with strong historical performance are likely to continue their momentum in the future and assets with poor performance will continue to decline (Jegadeesh and Titman, 1993). Therefore in a momentum strategy, well-performing assets are bought and poor-performing assets are sold. However, this approach typically relies on historical returns as the primary driver. This research introduces a novel perspective by proposing the use of a Geopolitical Risk Index as an alternative criterion for constructing a momentum strategy. This departure from the conventional norm of momentum investing aims to uncover how geopolitical risk, a multifaceted and often unpredictable

factor, can influence investment strategies.

The momentum strategies constructed in this thesis will use the Geopolitical Risk Index constructed by Caldara and Iacoviello (2022). The measure is constructed by calculating the share of newspaper articles related to negative geopolitical events and threats from all published articles in 10 major newspapers from the US, the UK, and Canada. In this thesis, the country-specific index, which is calculated for 44 countries, is used. The country-specific indices are derived from automated text-search outcomes within electronic archives of newspaper articles. In this thesis, the momentum investment strategies are constructed for six countries: China, Germany, France, Japan, Russia, and the United States. Each of these strategies is constructed individually with the main equity indices of these six countries. In general, each momentum strategy is constructed by shorting the main equity index if the country-specific GPR index has increased and buying the main equity index if the GPR index has decreased. The strategies are constructed this way, since when the GPR index rises, indicating increasing geopolitical uncertainty, the values of investments in that specific country often decrease (Agoraki et al., 2022). The strategy assumes that as the GPR decreases the investment returns increase. The methodology presented in this thesis tries to take advantage of this knowledge.

The primary objectives of this thesis are to assess the relationship between geopolitical risk and investment returns and to construct investment strategies based on this relationship that can adequately protect investments against geopolitical crises. The thesis will explore different variations of the GPR momentum strategy, by optimizing the sensitivity of the strategies with different cutoff values for the change in the GPR index, which determines whether the increase in GPR is significant enough to short the index. Also, the correlation between the equity index returns and the change in the GPR index is examined to choose the optimal time to make investment decisions based on past changes in the GPR index. In addition, an explorative analysis of the results is constructed by investigating the sector allocation of the equity indices and the exposure of different industries to changes in the GPR index as well as the effect of different geopolitical events on specific stocks and indices.

This thesis is subject to the following limitations and assumptions. First, the constructed investment strategy will exclude trading costs. This limitation is based on the notion that the trading costs would be small regardless because this thesis focuses on country-specific equity indices, which are often tracked by index-linked products such as passive mutual funds or ETFs, for which the trading costs are often very small compared to buying individual stocks. Second, the GPR index is constructed from the major newspapers in the US, United Kingdom, and Canada (Caldara and Iacoviello, 2022), and therefore the resulting index captures the US perspective for the geopolitical risk, which may not capture all the nuances of geopolitical risk. Third, because the country-specific equity indices do not necessarily include all relevant stocks in that country's equity market, the effect of geopolitical risk on returns of country-specific equities may not be as assumed. In other words, the proxy for equity returns in a specific country is not perfect.

This thesis is structured as follows. Section 2 provides a theoretical background, delving into the principles of momentum investment strategies, the Sharpe ratio

as a measure of risk-adjusted returns, and an introduction to the Geopolitical Risk Index. Section 3 gives a literature review, examining the impact of geopolitical crises on investment returns, the influence of geopolitical risk on investor behavior, and previous measures aimed at mitigating the effects of such crises. It also explores methods for measuring geopolitical risk. Section 4 provides an overview of the data sources, including different country-specific equity indices and the Geopolitical Risk Index. Section 5 outlines the methodology for constructing the investment strategies, detailing the structure of the momentum investment strategy, the incorporation of the Geopolitical Risk Index, and the parameters' tuning process. Section 6 presents the performance of the constructed strategies for the six countries. In the section 7 a sensitivity analysis of the constructed strategies is performed. Section 8 provides an explorative analysis of the results, with a focus on sector allocation of the main equity indices and specific geopolitical events. Finally, Section 9 offers concluding remarks, summarized key findings, and suggestions on avenues for future development.

2 Theoretical background

2.1 Principles of a momentum investment strategy

The general principle of momentum investing is based on the idea of buying winners and selling losers, as stated by Jegadeesh and Titman (1993). In other words well-performing assets are bought and poor-performing assets are sold. This paradigm revolves around the idea that assets with strong historical performance are likely to continue their momentum in the future and assets with poor performance will continue to decline. The performance of assets is based on historical asset returns (Jegadeesh and Titman, 1993). Therefore the strategy implies that the stock price may have a correlation with their past returns.

When constructing the momentum investment strategy, there are generally three parameters that need to be defined: ranking period, holding period, and rebalancing frequency (Griffin et al., 2003). The ranking period is the time period used to determine the winners and losers. The stocks are ranked by their returns during the ranking period, from which ten decile portfolios are formed. Each of the ten decile portfolios are equally weighted, i.e., the weight of each stock in the portfolio is one divided by the total number of stocks in that decile. The study made by Jegadeesh and Titman (1993) uses ten decile portfolios, which is usually the standard, but the portfolios can also be formed by dividing the stocks into different size samples, for example forming tercile portfolios instead of decile portfolios. After defining the different portfolios the top decile portfolio is defined as the winning portfolio and on the contrary, the bottom decile is defined as the losing portfolio. The winning portfolio is bought and the losing portfolio is shorted. The holding period defines the amount of time that this position is held. The rebalancing frequency determines how often the ranking is done to construct new winners and losers. The holding period and rebalancing frequency can be the same, meaning that after the holding period the position is closed and the ranking is done again (Jegadeesh and Titman, 1993). If the rebalancing period is shorter than the holding period then the strategy has overlapping portfolios.

In the study made by Jegadeesh and Titman (1993) the momentum investment strategies composed using 3 to 12-month ranking and holding periods, earn profits of about one percent per month for the following year (Jegadeesh and Titman, 2001). In addition, Jegadeesh and Titman (1993) show that the portfolio returns are not due to their systematic risk. In conclusion, using a momentum investment strategy, investors are able to earn significant profits.

2.2 Sharpe ratio

To characterize the performance of the investment strategy, a measure for assessing and comparing the performance of the constructed investment strategies is needed. The Sharpe ratio, introduced by Sharpe (1994), is a measure of risk-adjusted performance for an investment or a portfolio. It evaluates the return of an investment relative to its risk, with the risk being measured by the standard deviation of its returns. The formula for the Sharpe ratio is:

$$\text{Sharpe ratio} = \frac{R_p - Rf}{\sigma_p}, \tag{1}$$

where R_p is the return of the portfolio, R_f is the risk-free rate and σ_p is the standard deviation of the portfolio's excess return. The $R_p - R_f$ is the market risk premium, which is the excess return above the risk-free rate. Therefore the Sharpe ratio is the risk-adjusted return of the portfolio which is calculated by dividing the excess return by the standard deviation of the portfolio's excess return, in other words the ratio indicates the excess return per unit of risk associated with the excess return. A higher Sharpe ratio indicates a better risk-adjusted performance since it reflects a higher return for a given level of risk (Sharpe, 1994). The Sharpe ratio will be used in this thesis to measure the performance of the different momentum strategies.

2.3 Geopolitical Risk Index

The Geopolitical Risk Index is a measure constructed by Caldara and Iacoviello (2022). The measure is used to determine real-time geopolitical tension perceived by the press. The index is constructed through an automated text-search methodology applied to electronic archives of articles published in 10 major newspapers from the United States, the United Kingdom, and Canada. The value of the index is calculated by the share of articles related to negative geopolitical events from all articles published. Therefore, the underlying idea is that an increase in the frequency of certain keywords or phrases in news articles corresponds to a higher level of geopolitical risk.

Caldara and Iacoviello (2022) define geopolitical risk as a threat, realization, and escalation of negative geopolitical events related to wars, terrorism, and any tension among states and political actors that can affect the peaceful course of international relations. The construction of the index is based on a dictionary-based method, which specifies a dictionary of words whose occurrence in articles is associated with negative geopolitical events and threats. These words are divided into eight categories: war threats, peace threats, military buildups, nuclear threats, terror threats, the beginning of war, escalation of war, and terror acts. Therefore the index is constructed with two components, geopolitical threats (GPRT) and geopolitical acts (GPRA). Since using only a one-word search might lead to misclassification and measurement error, Caldara and Iacoviello (2022) use a search query that specifies two words or phrases whose joint occurrence indicates negative geopolitical events. The articles including the required two words or phrases meet the criterion for inclusion in the index.

The index is then constructed by calculating the share of articles, which are identified through the search query as articles discussing negative geopolitical events or threats, from all published articles. The index is constructed from 1985 and it is based on 10 major newspapers: the Chicago Tribune, the Daily Telegraph, the Financial Times, the Globe and Mail, the Guardian, the Los Angeles Times, the New York Times, USA Today, the Wall Street Journal, and the Washington Post. These newspapers were chosen by Caldara and Iacoviello (2022) to capture events that have global dimensions and consequences. The data from news articles is searched daily and monthly to construct the global GPR index as well as monthly to construct the

country-specific GPR index. The global index is constructed as described before, but the country-specific index is calculated for 44 countries by adding the name of the country or its capital or main city in the search query in addition to the required words associated with geopolitical risks. The country-specific index measures the exposure of specific countries to global risks and highlights geopolitical events that are relevant for individual countries or regions (Caldara and Iacoviello, 2022).

3 Literature review

3.1 Geopolitical crises and their effect on investment returns

In this thesis, the Geopolitical Risk Index is used as the geopolitical risk measurement as described in Section 2.3. Geopolitical risk is described as a threat, realization, or escalation of negative events that are associated with terrorism, wars, or any other tension between states or political actors that might disrupt or harm international relations (Caldara and Iacoviello, 2022). The measurement also includes events that do not involve violence or competition over territories, as international relations are often affected by alternative power struggles, for example the tensions between the US and North Korea (Caldara and Iacoviello, 2022). The market participants, entrepreneurs, and central banks view geopolitical risks as key determinants of investment decisions and stock market dynamics, as in general geopolitical risks affect the macroeconomic variables through several events such as loss of human life, destruction of capital stock, higher military spending, or increased precautionary behavior (Caldara and Iacoviello, 2022). The hypothesis of the thesis is that an increasing geopolitical risk decreases investment returns, and thus the effect of geopolitical crises on investment returns is investigated throughout this literature review.

The study made by Caldara and Iacoviello (2022) identifies multiple relations between the GPR index and economic variables. By using vector autoregressive (VAR) models for the United States in the period from 1985 to 2019, Caldara and Iacoviello (2022) seek to identify correlations between the GPR index and a range of economic variables. The VAR model suggests that a shock to geopolitical risk results in continuous declines in investment, stock prices, and employment. In addition, they find that the correlation between economic variables and the GPR index reflects the effect of the GPR index on the economic variables, rather than vice versa. Using cross-country data and country-specific indices, they also find that higher values of the GPR index are associated with a higher probability of economic disasters, which most likely affect investment behavior and investment returns. Finally, they perform a regression analysis to identify how the returns of different industries are affected by the increase in the GPR index. The idea behind this study is that different industries have different exposures to the increase in the GPR index. In more detail, stock returns in sectors with higher exposure to the GPR index drop relatively more than the aggregate market in response to shocks in the GPR index, and on the contrary sectors with lower exposure gain from geopolitical risks relative to the market. Therefore the assumption of the strategy only works if the sector allocation in the chosen equity indices are for the majority of the market capitalization in industries that are positively exposed to the GPR index. The effect of the GPR index on different industry returns is investigated further in Section 8.1.

Agoraki et al. (2022) analyze the impact of geopolitical risk on stock returns by estimating an augmented version of the Capital Asset Pricing Model with a fixed-effects OLS estimation method. In their study they use the GPR index constructed by Caldara and Iacoviello (2022) and monthly stock market indices from 22 different countries for the period 1985–2020. They show that the impact of geopolitical risks on stock

returns is negative and statistically significant. In more detail, one-unit standard deviation increases in the GPR index decrease stock returns by 10.53-42.12% of its sample mean. In addition to analyzing the effect of the GPR index on stock returns, the study also analyses the effect of economic policy uncertainty on stock returns by using the global economic policy uncertainty index (GEPU) and the economic policy uncertainty country index (EPU) constructed by Baker et al. (2016). The study shows that the impact of economic uncertainty on stock returns is also negative, but not as significant compared to the effect of the GPR index. Thus, it seems that the GPR index can be used as a determinant of stock market dynamics, as it has a negative impact on stock returns, and it gives more significant results compared to other indices, which solidifies the assumption of the thesis.

Similar results are obtained in the study made by Salisu et al. (2022), who show that GPR is a significant predictor of stock returns in most advanced economies. The study consists of monthly stock price data over a century for eight advanced economies comprising the G7 economies and Switzerland. The main result is that increases in GPR are expected to depress the stock markets of advanced economies, which suggests that advanced economies are also impacted significantly by the GPR which was not previously known. Thus, the advanced stock markets cannot serve as a good hedge against GPR. In addition, the study shows that the stock market suffers the most from impacts from GPR threats (GPRT) than their actual occurrence. In more detail, the scenario analysis of Salisu et al. (2022) indicates that when the GPRT increases by 10 %, stock returns fall for all countries, but when it decreases by 10 % returns rise, which further solidifies the assumption used in this thesis. Similar results are reported by Caldara and Iacoviello (2022), who analyze the responses of the stock market in the US due to geopolitical risk acts and threats. They find that a shock in acts (GPRA) results in a small and short-lived decline in stock returns with a sharp rise in the returns one month after the shock. On the other hand, a shock in the threat of geopolitical risk results in large recessionary effects as well as a decline in stock prices.

Yang and Yang (2021) study the impact of mixed-frequency geopolitical risk on stock market returns. They apply the mixed data sampling (MIDAS) approach to the GPR index constructed by Caldara and Iacoviello (2022), and find that real-time GPR shock has a lasting negative impact on stock returns. In more detail, from the quarterly, monthly, and weekly regression models, they find that the coefficients of GPR change are all negative and statistically significant when studying the GPR effects in U.S. stock markets. Kollias et al. (2013) study the impact of terrorism on stock-bond covariance in European countries. The results indicate that terrorist attacks trigger a flight-to-safety effect in France and Germany, which suggests that in these two countries increase in GPR due to terrorist attacks, can trigger a decrease in their equity indices. Thus, multiple researches have found a negative correlation between the GPR index and stock returns, which is the main assumption of the strategies constructed in this thesis.

3.2 The effect of geopolitical risk on investor behavior

Investor behavior and sentiment are important factors affecting decision-making and asset prices (He, 2023). In the previous section, geopolitical risk was found to affect investment returns, but studying investor behavior and sentiment during geopolitical risk shocks can help explain why the returns decrease. According to Fisher and Statman (2000), there is a relationship between the sentiment of investors, for both individual investors and Wall Street strategists, and future stock returns. Thus, it is important to study the effect of geopolitical risk on investor sentiment, which consequently affects investment returns.

He (2023) study the relationship between geopolitical risk index and investor sentiment in the US stock market. The results showed that GPR has significant negative effects on investor sentiment, meaning that higher geopolitical risks decrease investor sentiment either directly or indirectly. The direct effect of geopolitical risk on investor sentiment is due to uncertainty aversion, which is why geopolitical events as significant external uncertainties have dampening effects on investor sentiment. The indirect effects of geopolitical risks on investor sentiment come through three channels: real economic activity, investments, and the stock market. Increased levels of geopolitical risk result in a sustained decline in real activity and economic growth, which in turn impacts consumer confidence and investor sentiment negatively since a decline in economic activity can lower investors' expectations about the future and increase their concerns. In addition, geopolitical risks affect investments, since increased geopolitical risk is a form of uncertainty, and increased uncertainty is believed to cause reductions in investments, which will then lower investor sentiment in the stock market. The final indirect channel through which geopolitical risk affects investor sentiment is through the stock market, which is according to the section 3.1 largely affected by geopolitical risks. As the performance of the stock market is a key determinant of an investor's decision, it naturally affects the sentiment of investors. (He, 2023).

The results from He (2023) indicate that the change in the GPR can affect investor sentiment, but not the other way around. The response of investor sentiment was found to be more significant in the short and medium term than in the long term, and the response is more sensitive to domestic geopolitical events. Thus, when constructing the strategies in this thesis, the investor should react quickly enough to the changes in the GPR to exploit the opportunities coming from the expected investors' response. In addition, since the response is most sensitive domestically, it is acceptable to only use the country's own GPR change to determine the investment decisions in the country's equity index, and not include multiple country-specific GPR indices into one strategy.

Wang et al. (2019) study the relationship between geopolitical risk and investment, and find a significant negative relationship between firm-level corporate investment and the GPR index, as when the GPR index doubles, next-quarter investments declined by 14% of its sample mean. The negative relationship most likely comes through the real options channel, which relies on the assumption that asymmetric adjustment costs make (real) investments irreversible, and thus a firm is more sensitive to negative states because it is costlier for the firm to adjust investment downward than upward (Wang et al., 2019). Geopolitical shocks affect the investments of larger corporations, for

example after the Paris attack of 2015, the chief executive officer of Siemens warned that the increased geopolitical risk is damping corporate investment plans and raising concerns about a global growth slowdown (Wang et al., 2019).

In addition to affecting the investment behaviors of individual investors and corporations, the geopolitical risk also affects the international capital flows according to the study made by Feng et al. (2023). The results of the study show that capital flows, both outflows, and inflows, for emerging and advanced countries experience significant contractions when the geopolitical risk increases, which is due to the fact that geopolitical risk is a key determinant of investment decisions and thus ultimately influences capital flows. The results confirm the conventional assumption that increasing geopolitical risk triggers the flight home effect, meaning that domestic agents decrease their purchase of foreign assets and foreign agents decrease their purchase of domestic assets when geopolitical risk rises (Feng et al., 2023). In addition, the study made by Feng et al. (2023) shows that global foreign direct investment shows a flight-to-safety phenomenon when geopolitical risk rises.

3.3 Previous measures on protecting investments from the effects of geopolitical crises

In general, investors hedge their investments against different uncertainties, to ensure that their investments do not decrease in value significantly in times of turmoil. As geopolitical risk is seen as an external uncertainty (He, 2023), investors should hedge their investments against changes in geopolitical risk. Investors often hedge their investments by diversifying their portfolios, but since during significant geopolitical crises most asset classes decline, a diversified portfolio is not necessarily adequate to protect the value of investments (Hasan et al., 2021). Therefore, in previous studies the use of safe-haven assets has been used to protect investments from geopolitical risks (Hasan et al., 2021). Safe-haven is defined by Baur and Lucey (2010) as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market turmoil. The more specific property of a safe-haven asset is the nonpositive correlation with a portfolio on extreme market conditions, meaning that it can be used to compensate the investor for losses since the price of the safe-haven asset rises when the price of the other assets or portfolio falls (Baur and Lucey, 2010). Thus, as increasing geopolitical risk has a negative relationship with stock returns, the use of safe-haven assets has been a popular choice to sustain investment values at adequate levels during geopolitical turmoil. Many studies have been carried out to evaluate the performance of different safe-haven assets in protecting investments against geopolitical risks, some of which criticize their efficiency and adequacy.

Often, precious metals, government bonds, currencies, and alternative assets are seen as traditional safe-haven assets (Kopyl and Lee, 2016). However, there is a weakness in using safe-haven assets to protect investments against geopolitical risks. An analysis done by Kopyl and Lee (2016) demonstrates that during significant market turmoil, some of the strongest safe-haven assets lose their safe-haven status, and thus during significant changes in the GPR index the use of traditional safe-haven assets

may not be sufficient to protect investments. In addition, the study made by Kopyl and Lee (2016) highlights the fact that identifying adequate safe-haven assets with the data available before the crises is difficult since the predictive conditional market exposures for even the strongest safe-haven assets are often statistically insignificant. Thus, even though some of the traditional safe-haven assets are adequate in protecting investments during turmoil, the identification of these assets beforehand is very difficult.

Gold is often seen as one of the most traditional safe-haven assets during uncertainty, as it is considered a unique raw material due to its value-retention property, especially in troubled times (Triki and Maatoug, 2021). For example, Triki and Maatoug (2021) examine the relationship between the US stock market and the gold price during geopolitical tension, and the results indicate that during the period from 1985 to 2018, gold was an adequate diversifier and safe-haven asset, especially during high geopolitical tension. Additionally, the results show that gold was a good asset to hedge against the volatility of S&P 500, especially during market turmoil. Similar results are attained by Baur and Lucey (2010) who find that gold is a safe-haven for stocks in the United States, the United Kingdom, and Germany after extreme negative stock market shocks. In addition, they find that the safe-haven property is short-lived. Baur and Smales (2020) find in their study that gold and silver display consistent safe-haven properties during extreme increases in the GPR index.

Kamal et al. (2022) investigate different safe-haven assets and their safe-haven properties before and after the COVID-19 pandemic. They find that gold lost its safe-haven features during COVID-19, and therefore investors should not take gold as a granted safe-haven asset while forming their portfolios and that it would be rational to rethink how safe the safe-haven assets really are. Similar results are found in the study made by Akhtaruzzaman et al. (2021). They find that gold acted as a safe-haven asset at the beginning of the pandemic, but then lost its safe-haven status to stock markets in March 2020 when the US government intervened with monetary and fiscal stimulus packages to overcome the pandemic's economic consequences. This is an interesting result, as gold remained as a safe-haven asset throughout the 2008 global financial crises (Akhtaruzzaman et al., 2021), and therefore different crises and the actions made by the government and the market affect the safe-haven properties of different asset classes, and it is difficult to predict these outcomes beforehand.

Thus, even the most traditional and strongest safe-haven assets can lose their safe-haven properties during different crises, and thus the use of these assets may not be enough to protect investments. In light of this evidence, safe-haven assets are not guaranteed to keep their safe-haven properties, and these assets are often identifiable only ex-post. This could suggest using alternative measures for investors to protect their portfolios against geopolitical risks, which could be argued to be exogenous in nature. The strategies constructed in this thesis could provide more reactive protection against different shocks in the GPR index, compared to the use of traditional safe-haven assets.

3.4 Measuring geopolitical risk

Because geopolitical risk is seen as one of the key determinants of investment decisions (Caldara and Iacoviello, 2022), it is important to have efficient and accurate measures to calculate geopolitical risks in a timely manner. There are multiple different methodologies and applications of geopolitical risk measures. These measures can be divided into three categories, based on their construction: empirical models of asset prices, textual analysis of news, and expert ratings (Karagozoglu et al., 2022). The empirical models, for example the GEOVOL model (Engle and Campos-Martins, 2020), are estimated based on actual price changes of financial assets due to the common volatility shocks to financial markets. The textual analysis models, such as the GPR index (Caldara and Iacoviello, 2022), are constructed by computing the relative frequency of the text published in newspapers (or some other data source) that contains topics related to geopolitical risks. The expert ratings are constructed by agencies or researchers using the information on geopolitics and analysts' insights on the likelihood of such events happening in the future (Karagozoglu et al., 2022).

The different measures differ in their information sources, methodologies, and data frequency, but they are all mostly used in the literature to investigate the impact of geopolitical risk on different aspects such as the economy and financial markets. Engle and Campos-Martins (2020) discuss the application of the GEOVOL measure in hedging geopolitical risk, as if the GEOVOL factor loadings on assets differ, it is possible to reduce the exposure to geopolitical risk. The GPR index constructed by Caldara and Iacoviello (2022) has been widely used multiple times to study the impact of geopolitical risks on financial markets and different macroeconomic events. The expert ratings, such as the ICB indicator, have been used also in multiple researches to explain the relationship between geopolitical risks and different aspects, such as stock returns (Karagozoglu et al., 2022).

Karagozoglu et al. (2022) compare the different measures to investigate their ability to capture changes in geopolitical risks. Their overall results suggest that measures based on asset prices and textual analysis outperform the performance of measures based on expert ratings. This result is most likely due to the fact that asset prices and newspaper articles contain information that directly reflects the markets' collective assessment of the impacts of geopolitical events on financial markets (Karagozoglu et al., 2022). The study suggests that short-term investors and high-frequency traders can rely on the empirical and textual analysis models as the primary geopolitical risk indexes in their decision-making. As the GPR index constructed by Caldara and Iacoviello (2022) is one of the most widely used measures of geopolitical risk and since textual analysis measures perform well and can be used in short-term investment decisions due to high reporting frequency (Karagozoglu et al., 2022), this thesis will also use the GPR index to measure geopolitical risk.

4 Data

4.1 Country-specific equity indices

The momentum investment strategies in this thesis are constructed for the main equity indices of six countries. These countries are China, Germany, France, Japan, Russia, and the United States. For each country, the momentum strategy is based on the change in the country-specific GPR index, to determine whether the investor should buy or short the main equity index of that country. The chosen equity indices for each country are listed in Table 1.

The daily returns for all countries are denominated in euros and collected from the beginning of 2010 to the end of October 2023. The number of data points for the different country-specific indices varies, since the exchanges where equities are traded are open during different days, due to different holidays in different countries. These variations do not affect the construction of the strategy, because in the investment strategy, monthly returns are used. The compounded monthly returns which are used when constructing the strategy are calculated from the daily returns.

Country	Equity index
China	SSE
Germany	DAX
France	CAC40
Japan	Nikkei225
Russia	MOEX
The United States	S&P 500

Table 1: Main equity indices for China, Germany, France, Japan, Russia and the United States

For China, the Shanghai Composite index (SSE) is chosen as the main equity index. Shanghai Composite index, is a stock market index that reflects the performance of all stocks listed on the Shanghai Stock Exchange (CSI, 2020). The DAX index is chosen as the main equity index in Germany. This index tracks the performance of the 40 largest companies listed on the Frankfurt Stock Exchange which fulfill certain quality and profitability requirements (Quontigo, 2023). The main equity index in France is the CAC40 index. The CAC40 index tracks the performance of the 40 largest and most actively traded stocks listed on Euronext Paris (Euronext, 2023). For Japan, the Nikkei Stock Average (Nikkei225) is used as the main equity index. The Nikkei225 index tracks 225 domestic common stocks in the Prime Market of the Tokyo Stock Exchange (Nikkei, 2023). MOEX Russia index is chosen as the main equity index for Russia. The index reflects the prices of the most liquid Russian stocks of the largest and developing Russian companies listed on the Moscow Exchange (Exchange, 2021). Finally, for the United States, the S&P 500 index is used as the main equity index. This index tracks the leading 500 companies listed on stock exchanges in the United States (Indices, 2023).

The performances of these six equity indices between 2010 and 2023 are illustrated in Section 4.2 together with the development of country-specific GPR indices. The performance is based on an index of the daily returns, indexed at 1 at the beginning of the sample period.

4.2 Geopolitical Risk Index

This thesis uses the Geopolitical Risk Index by Caldara and Iacoviello (2022) which determines the geopolitical tension perceived by the press both globally and country-specifically. Summarizing the more detailed explanation of the GPR index in Section 2.3, the index is constructed through an automated text search-method for 10 major newspapers to identify the share of news articles related to a threat, realization, and escalation of negative geopolitical events from all published articles. This thesis will use the country-specific GPR index, which is calculated monthly by measuring the share of articles simultaneously mentioning geopolitical risks together with the name of the country (or its main cities) in question.

The countries used in this thesis are chosen to capture different geographies to assess the effect of the GPR index on equity indices in different regions. In addition, these countries have had major variations in the GPR index over the current century, and therefore they can be used to assess how these fluctuations have impacted the returns of the equity indices. Figures 1, 2, 3, 4, 5 and 6 illustrate the development of the GPR index and the performance of the equity index for each of the chosen countries.

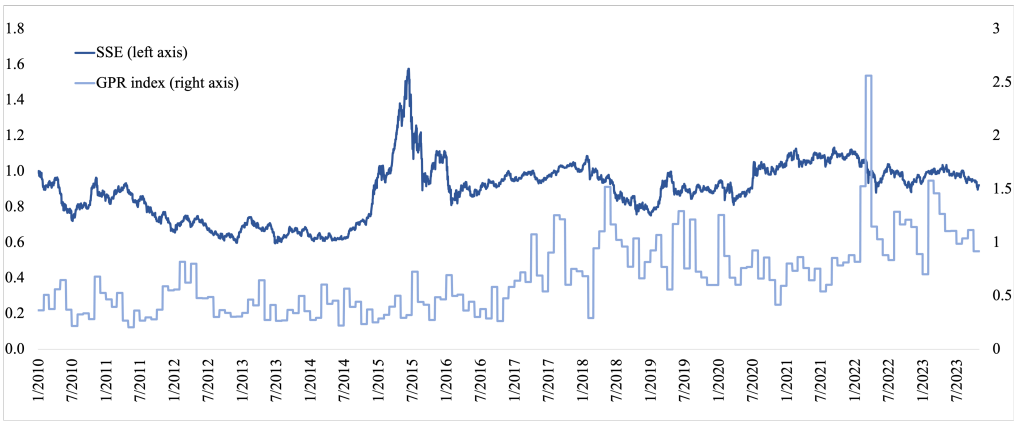

Figure 1: Development of the GPR index of China (`GPRC_CHN` in Caldara and Iacoviello (2022)) and the SSE Composite index between 1/1/2010-31/10/2023.

Figure 1 shows that the GPR index in China remains relatively low until mid-2017. During this time the SSE index slowly declines until a significant increase in 2015 and it seems that the GPR index does not have a strong correlation with the equity index. This may be due to the fact that the fluctuations in the GPR index remain small during this time period and therefore the development of the equity index is dependent on other factors. The first two larger fluctuations in the GPR index are during 2017

and 2018, when the index rises to a value of above 0.6. From the beginning of 2018, the SSE index starts to decrease, and therefore we can conclude that there may be a negative correlation between the GPR index and the SSE index with a lag. In addition, during 2022 there is a large increase in the GPR index. During this period the SSE index decreases. After the large spike in the GPR index, it decreases significantly, during which the SSE index starts to rise, which again suggests a negative correlation between the variables. To conclude, there appears to be a negative correlation between the GPR index of China and the SSE index when the fluctuation of the GPR index is significant.

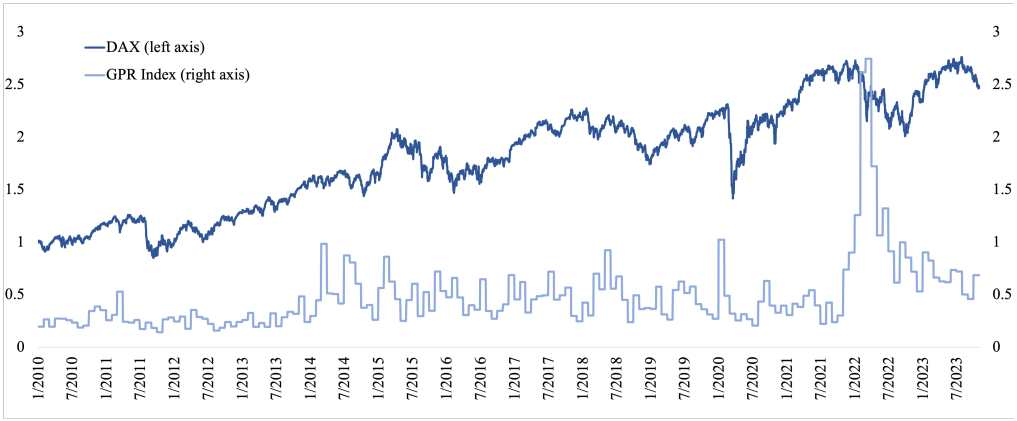

Figure 2: Development of the GPR index of Germany (GPRC_DEU in Caldara and Iacoviello (2022)) and the DAX index between 1/1/2010-31/10/2023.

For Germany, Figure 2 illustrates similar trends that were seen in China, for example when the GPR index remains relatively stable, there is no evident correlation between the equity index and the GPR index. Between 2014 and 2019, there are more fluctuations in the GPR index and in the DAX index, and therefore during more uncertain geopolitical times the equity index seems to fluctuate as well. In 2018 the GPR index increases and remains at a higher level for the whole year, after which the DAX index decreases significantly. At the beginning of 2020, the GPR index increases significantly, and shortly after the DAX index decreases in value significantly. After the major fluctuations in the beginning of 2020, the GPR again remains stable with small values, during which the DAX index increases. The GPR index increases to maximum values during 2022, which also interrupts the increase in DAX as the index starts to decrease. Thus, after significant increases in GPR, the DAX decreases, and therefore there may be a negative correlation with some lag between the variables. This indication suggests that it takes some time for the market to react to negative geopolitical events, and therefore the fluctuation in the equity index happens after some time from the fluctuation in the GPR index.

Figure 3 shows that the development of the GPR index and the equity index in France is very similar to the case in Germany in Figure 2 during the last four years. Therefore also in the case of France, it seems that during large fluctuations in the GPR index, there is a negative correlation between the GPR index and equity index, and while the GPR index remains stable with smaller values the equity index often

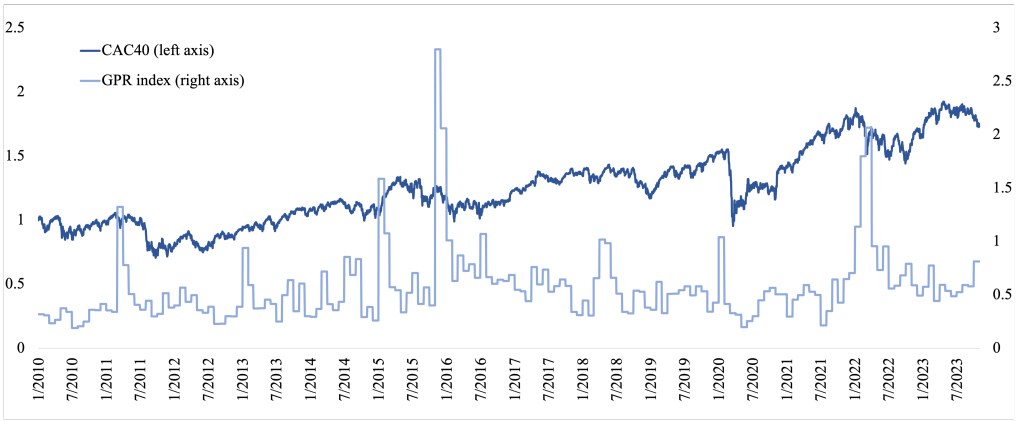

Figure 3: Development of the GPR index of France (`GPRC_FRA` in (Caldara and Iacoviello, 2022)) and the CAC40 index between 1/1/2010-31/10/2023.

rises. In contrast to China and Germany, in France there are large fluctuations in the GPR index during the whole period. These large fluctuations in the GPR index do not result in significant decreases in the CAC40 index, but if the index is compared to the DAX index in Figure 2 the CAC40 index seems to increase slower. The development of the indices DAX and CAC40 are otherwise very similar due to the close regional relationship, but large values and fluctuations in the GPR index seem to slow down the increase in the equity index, as can be seen in the France case in Figure 3.

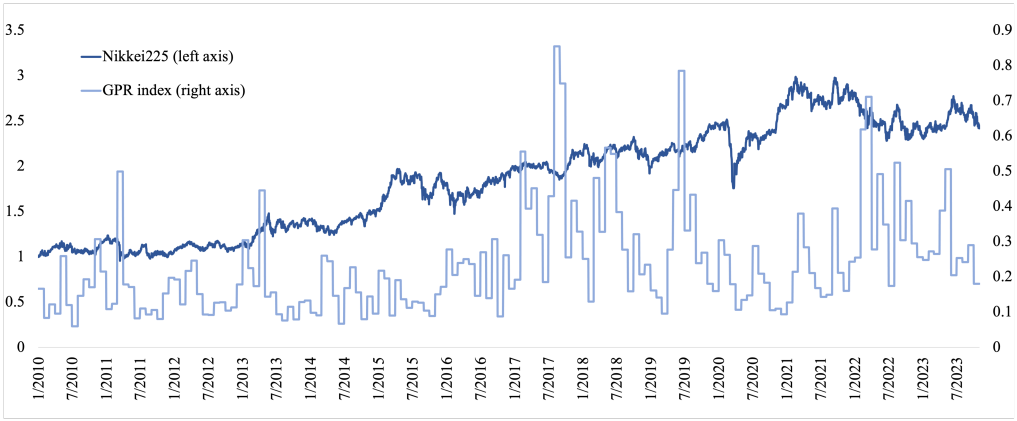

Figure 4: Development of the GPR index of Japan (`GPRC_JPN` in (Caldara and Iacoviello, 2022)) and the Nikkei225 index between 1/1/2010-31/10/2023.

Figure 4 illustrates the development of the GPR index of Japan and the Nikkei225 index. It can be seen that in Japan the GPR index remains in lower values, but there are still some major fluctuations. Since the value of the GPR index remains under the value of 1, it is more difficult to identify the relationship between the equity index and the GPR index. Therefore for smaller values in the GPR index, further analysis of the correlation between the GPR index and equity index is needed to identify the nature of the relationship between these two variables, which is done in Section 5.2.

Figure 5 shows that in Russia the GPR index rises much higher than in the other

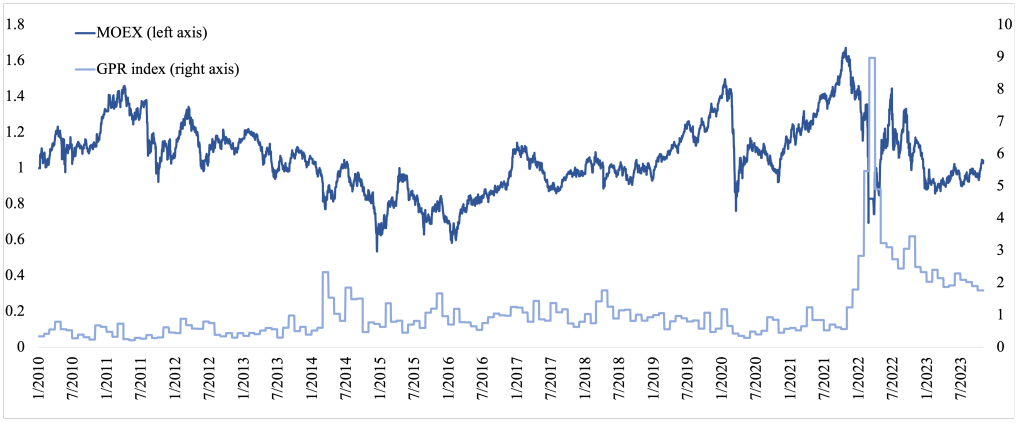

Figure 5: Development of the GPR index of Russia (GPRC_RUS in (Caldara and Iacoviello, 2022)) and the MOEX index between 1/1/2010-31/10/2023.

countries. The MOEX index has not increased in the 13 years as much as the other main equity indices of the other countries, which may be due to the larger GPR values and fluctuations. In Figure 5 there are signs of a negative correlation between the two indices for example during the most significant increase in GPR at the beginning of 2022 the MOEX index decreased significantly and as the GPR index decreases significantly after the spike the MOEX index increases. As the GPR index stabilizes after the fluctuations in 2022, the MOEX index stabilizes and starts to increase during 2023.

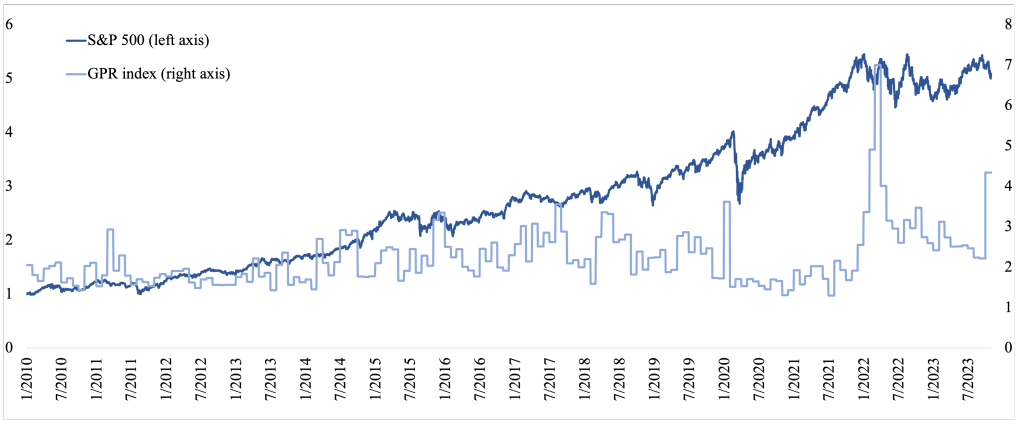

Figure 6: Development of the GPR index of the Unites states (GPRC_USA in (Caldara and Iacoviello, 2022)) and the S&P 500 index between 1/1/2010-31/10/2023.

Figure 6 illustrates the development of the GPR index in the USA and the S&P 500 index. The GPR index has larger values compared to the other countries, with the exception of Russia. Since the GPR is calculated from major newspapers based in the US, Canada, and the UK, it is expected that the index can detect geopolitical events from the US more frequently and accurately. Therefore the GPR in the US is larger, even if the geopolitical tension is not necessarily more significant compared to the other countries. The S&P index increases steadily from 2010 to 2020, and therefore

in the US it seems that even larger fluctuations in the GPR do not necessarily affect the equity index returns. At the beginning of 2020, the GPR index has a spike, after which the S&P 500 index decreases significantly. After the spike, the GPR index decreases to its lowest value, during which the S&P 500 index increases rapidly. At the beginning of 2022, the GPR index starts to increase rapidly which interrupts the increase in the S&P 500 index. To conclude, also in the case of the US it seems that there is a negative correlation between the two indices, but the correlation is evident only with larger fluctuations compared to the other countries.

To more efficiently compare the different country-specific GPR indices, descriptive statistics of the different indices are plotted. Comparing and evaluating the statistics helps construct the optimal investment strategy which is based on the changes in the GPR index.

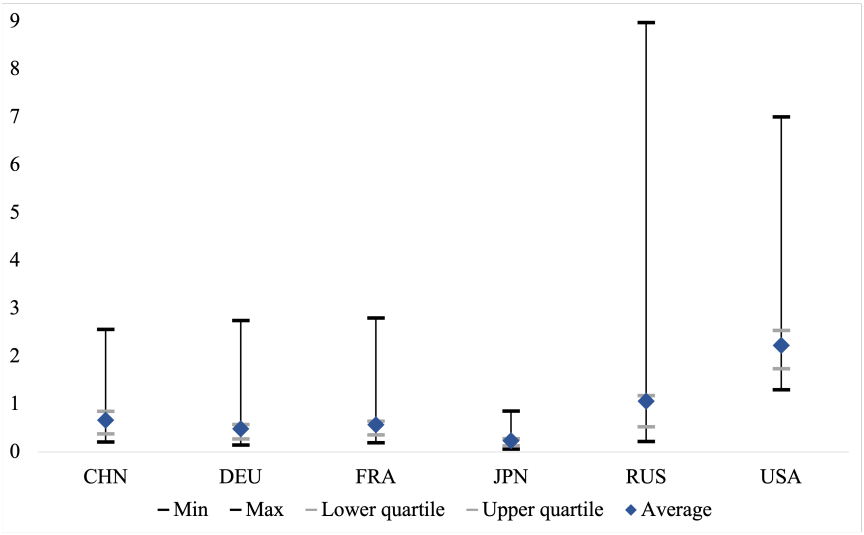

Figure 7: Average, minimum, maximum, lower quartile and upper quartile of monthly country-specific GPR indices

Figure 7 illustrates the averages, minimum values, maximum values, lower quartiles and upper quartiles for each of the country-specific GPR indices. From Figure 7 it can be seen that the GPR indices for China, Germany, and France resemble each other. Japan has the least variation in the GPR index, with the maximum and minimum of the index close in value. Russia and the USA have more variation in their GPR index, with also averages above the other countries. For all of the countries, the lower and upper quartiles are close to the average value, and therefore it seems that large fluctuations from the average value are rare. In addition for all of the countries, the average of the index is significantly closer to the minimum value than to the maximum value, and therefore we can conclude that for majority of the time the GPR exhibits lower levels, and larger values for GPR are not as frequent.

5 The investment strategy

5.1 The momentum investment strategy

The objective of the investment strategies in this thesis is to anticipate changes in the returns of the main equity indices of six countries due to changes in geopolitical tension. The strategies are based on the assumption that increasing geopolitical tension will decrease the future returns of investments. Thus, the strategy uses past changes in geopolitical tension in a specific country to make monthly investment decisions to the main equity index of the country in question. The strategy is constructed for six countries: China, Germany, France, Japan, Russia, and the United States. The momentum investment strategy is constructed for all six equity indices individually. Contrary to the traditional approach, each momentum strategy is based on the change in the country-specific GPR index instead of past returns. The change in the GPR index then determines whether the investor should buy the equity index or sell it short. Therefore the momentum investment strategy constructed will follow the basic principle described in section 2.1, without the portfolio construction due to the fact that there is only one equity that is studied in each strategy. The strategies will use one month as the ranking period and holding period, meaning that the monthly change in the GPR index determines whether the index is a winner or loser and the index is sold or bought based on this, and the position is then held for one month. The rebalancing frequency will also be one month, which means that each month the index is shorted or bought based on the change in the GPR index.

For each country, the monthly change in the GPR index is calculated by subtracting the monthly GPR index value from the previous month's value, resulting in a data range from 2/1/2010 to 31/10/2023. The change in the GPR index is then used to determine whether the investor should buy the equity index or short it each month. The hypothesis is that increasing GPR index results in decreasing returns for investments. Therefore if the GPR index for a specific country has increased, the returns for the corresponding country's main equity index are assumed to decrease. In other words, it is hypothesized that there is a negative correlation between the GPR index and the returns of the equity index. Therefore, if the change in the GPR index is large enough, the strategy shorts the equity index for one month, and if the change is not significant the strategy buys the equity index. The optimal cutoff value determining if the change is significant enough to short the index, is determined for each country individually by using an optimization tool to choose the cutoff value that results in the strategy with the largest Sharpe ratio. The cutoff values are discussed in more detail in section 5.3.

In addition, as observed in section 4.2 the correlation between the GPR index and the equity index return might be lagged, and therefore skipping periods will be used. This means that the change in the GPR index does not affect investment decisions in the current month but rather in the next month or the month after that, and therefore the buy and short positions are implemented with a lag which in this case is referred to as the skipping period. In addition, since the GPR index value is updated with a month's delay, the change in the GPR index cannot be used for investment decisions in the same month, and therefore the use of skipping at least one period is mandatory. The

correlations are studied in more detail in section 5.2, to determine optimal skipping periods for each country.

To summarize, the strategy is based on the change in the GPR index, with the idea that an increasing country-specific GPR index in the past will be followed by decreasing returns in the equity index of that country in the future. For each country, the cutoff value that results in the best-performing strategy is determined. The cutoff value determines the position in the equity index, i.e., buy or short, which is implemented with a lag depending on the correlation between the country-specific GPR and equity index.

5.2 Correlation between the change in geopolitical risk and returns

To determine how long it takes for the change in the GPR index to affect the returns of the equity index, the correlation between these two variables is examined. For different countries, the time it takes for the market to react to changes in geopolitical tension may differ, and therefore the strategy should take this into account by using skipping periods. This means that if the correlation between the change in the GPR index and the equity index returns is lagged, the investor should not immediately make the investment decision based on the change, but rather after the skipping period which is equivalent to the lag observed in the correlation. Because the strategy assumes that increasing GPR index results in decreasing returns, the strategy should apply lags where the correlation between the two variables is the most negative. For example, if the change in the GPR index between the current month and the last month is negatively correlated to the returns of the equity index two months ahead, then the strategy should short the equity index after two months. As mentioned in Section 5.1, the use of skipping periods is mandatory for each country. This is due to the fact that the GPR index for each month is updated at the beginning of the next month, and therefore the investor can know the monthly change only after the month has ended. This means that a skipping period of at least one month is needed for each strategy.

	ΔGPR(t,t-1) CHN	ΔGPR(t,t-1) DEU	ΔGPR(t,t-1) FRA	ΔGPR(t,t-1) JPN	ΔGPR(t,t-1) RUS	ΔGPR(t,t-1) USA
Equity index return (t)	-0.02	-0.03	0.07	-0.06	-0.12	0.02
Equity index return (t+1)	**-0.09**	0.06	0.04	**-0.11**	**-0.05**	0.06
Equity index return (t+2)	-0.06	**-0.08**	**-0.06**	0.05	0.08	**-0.13**
Equity index return (t+3)	0.02	-0.03	-0.06	0.13	0.09	-0.02
Equity index return (t+4)	0.02	0.04	0.06	-0.06	-0.01	0.06

Table 2: Correlations between monthly changes in country-specific GPR indices and the returns of country-specific equity indices with different lags. In the table, t denotes the current month, and $t+1$ to $t+4$ denotes the following months. Here *Equity index return* denotes the returns of country-specific equity indices explained in Section 4.1. $\Delta GPR(t, t-1)$ is the change in the country-specific GPR index between the month $t-1$ and the month t. Highlighted cells are the negative correlations with the largest absolute values, which determine the optimal skipping periods.

Table 2 shows the correlations between the monthly changes in the country-specific

GPR indices and the returns of country-specific equity indices defined in Section 4.1 with different lags. The correlations are calculated for the same month's equity index returns as well as for the equity index returns in future months. For certain lags, the correlation between the change in the GPR index and equity returns is negative, which justifies the assumption of the thesis that increasing GPR index results in negative returns. The highlighted correlations in Table 2 are the negative correlations with the largest absolute values for each country, which determine the optimal skipping periods. The correlations in the first row are the correlations of the change in the GPR index between the last month and the current month to the returns of the equity index in the current month. These correlations cannot be used, due to the lag in the reporting of new GPR index values mentioned before.

For China, Japan, and Russia, the negative correlation with the largest absolute value is between the change in the GPR index from month $t-1$ to t and the equity index returns in month $t+1$. Therefore in the strategy constructed for these countries, a skipping period of one month is used, meaning that the equity index is shorted at the beginning of month t if the change in the GPR index between month $t-2$ and $t-1$ is at least as large as the cutoff value, and otherwise the index is bought. For Germany, France, and the United States the negative correlation with the largest absolute value is between the change in the GPR index from month $t-1$ to t and the equity index returns in month $t+2$. Thus, the strategies constructed for these countries will implement a skipping period of 2 months, meaning that the strategy shorts the equity index at the beginning of month t if the change in GPR index between months $t-3$ and $t-2$ is at least as large as the cutoff value. In the case of France, the correlation between the change in the GPR index and the returns of the equity index after three months is the same as for the returns of the equity index after 2 months. In this thesis, the skipping period of 2 months will be used for France, as this option results in better performance.

5.3 Change in the Geopolitical Risk Index

After the skipping periods have been determined for each country, the optimal cutoff value for the change in the country-specific GPR index can be calculated for each of these strategies. Each month the change in the GPR index between the last month and the current month is calculated to determine whether the investor should short or buy the equity index. Because in Section 4.2 the data suggested that the returns are not affected by small changes in the GPR index, but rather only by larger changes, there should be some variable to determine whether the change is significant enough. Therefore it is crucial to determine a cutoff value, which is the value of the change in the GPR index that is seen as large enough to affect the returns of the equity index negatively. To determine the range of cutoff values that are most likely optimal for each country, the statistics of the monthly changes in the GPR index are examined. Monthly change for month t is calculated as the change in the GPR index between month $t-1$ and t.

Figure 8 shows the average, minimum, maximum, lower quartile, and upper quartile of monthly changes in the GPR index for each of the six countries. For each country, the average change is close to zero, with also the upper and lower quartiles close to the

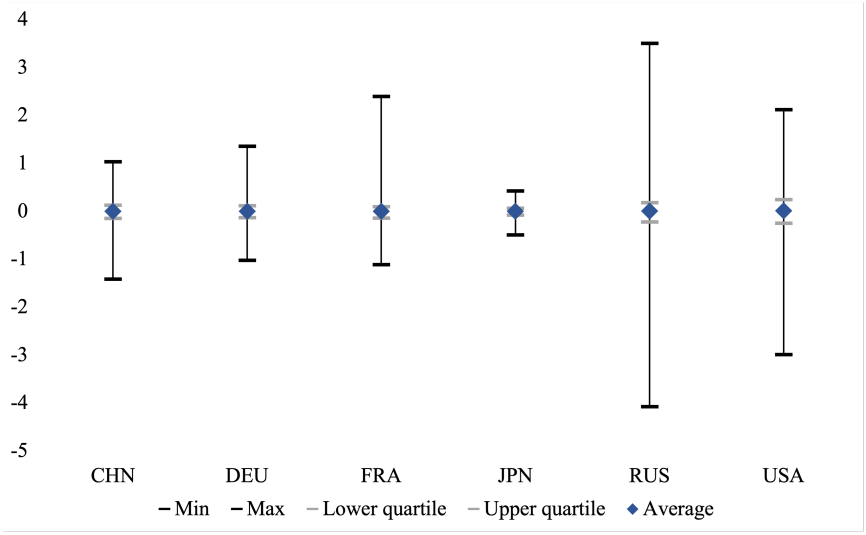

Figure 8: Average, minimum, maximum, lower quartile, and upper quartile of monthly changes in country-specific GPR indices

average. Thus, it seems that for the majority of time, the change in the GPR index is small. The exceptions are Russia and the US, where the quartiles are slightly further away from the averages. Because the strategy shorts the equity index if the change in the GPR index is large enough, the cutoff values for each country should be chosen so that they are positive but below the maximum value. The optimal cutoff value is most like not close to the maximum value since then the strategy is only able to react to very significant changes which are evidently rare. Simply put, the strategy should disregard changes that are so small that they do not affect the investors' behavior but not too large that the strategy remains reactive enough.

The quartiles help to think about the possible optimal ranges for the cutoff values since they indicate if large changes in the GPR index are common and consequently expected in the country. If the changes are common, investors are most likely used to seeing negative geopolitical news from these countries and therefore are not impacted as easily to change their investments due to these news. Thus, if the quartiles are further away from the average, which for all countries are close to zero, then large changes in the GPR index are more common in that country, which means that the investors are more likely to not react to small changes since they are more common and therefore do not rise immediate action. If the quartiles are near the average then even small changes are not as common in the country, and therefore even small fluctuations can make the investors stressed about the geopolitical state of the country, which then results in a decrease in the returns of the equity index.

According to Figure 8, the upper and lower quartiles for the GPR index changes are different for the six countries, and thus the cutoff values are also most likely different. For Japan, the maximum value for the change in the GPR index is the smallest, and therefore the optimal cutoff value is most likely the smallest, in other words, also small changes in GPR will affect the strategy's investment decisions. The upper and lower quartile values for China, Germany, and France are close to each other and therefore

the cutoff value will most likely be in similar ranges in these countries. For Russia and the United States, the quartiles are further away from the average compared to the other countries, and therefore the cutoff value is most likely larger for these countries, to make sure that the strategy does not react to changes that do not affect the market.

In this thesis the Sharpe ratio (Sharpe, 1994) is used to measure the performance of the investment strategy. Therefore the optimal cutoff value is chosen so that the Sharpe ratio of the returns in the investment strategy is maximised. The optimal cutoff value could be solved manually by trying all positive values below the maximum value and calculating the Sharpe ratio, but for efficiency optimization tools can be used. The optimal value for the cutoff value can be calculated using the Solver tool in Microsoft Excel. The Solver add-in is a tool in Excel that helps to find an optimal solution to a problem by adjusting the values in a set of cells according to certain constraints. This thesis will use the evolutionary method in the Excel Solver to identify the optimal cutoff value. The evolutionary method is based on a genetic algorithm to find the optimal or near the optimal value (Powell and Batt, 2011). The algorithm generates multiple solutions to the optimization problem and the solutions with high values for a maximization problem are preserved, while solutions with low values are deleted. By testing different solutions, the algorithm attempts to generate the solution after which the objective cannot be improved further. Since the final solution might be only near the optimal, in this thesis values close to the generated value will be manually tested. The evolutionary method needs constraints on the variable, and thus the cutoff value will be set between zero and the maximum change in the GPR index. The optimization for the cutoff value will be performed for each country in Section 5.3.1.

5.3.1 Determining the cutoff value of the change in the Geopolitical Risk Index

For determining the optimal cutoff values for the change in the GPR index, the performance of using different cutoff values in the strategies constructed will be compared. The Sharpe ratio (Sharpe, 1994) will be used as the performance measure. The Sharpe ratio is annualized, by multiplying the calculated Sharpe ratio with the square root of 12. Thus, the annualized Sharpe ratio has the following formula:

$$\text{Sharpe ratio} = \frac{R_s - R_f}{\sigma_s}\sqrt{12}, \tag{2}$$

where R_s is the average of the monthly strategy returns, R_f is the risk-free rate and σ_s is the standard deviation of the strategy's returns. The Sharpe ratio 2 is calculated for each country using the optimal skipping periods determined in Section 5.2. The risk-free rate will be set to zero for simplicity, and thus the Sharpe ratio values may not be realistic representations of the risk-adjusted performances. Nonetheless, it measures the ratio between the returns and the volatility, and this ratio is maximized when choosing the cutoff value for each strategy. By using the evolutionary method in the Solver, the optimal value for the cutoff value is determined, by maximizing the Sharpe ratio of the strategy by changing the value of the cutoff value. In the Solver the cutoff value is constrained to be between zero and the maximum change in the GPR

index. The Solver returns a value that is optimal or near the optimal, and thus also Sharpe ratios for cutoff values near the Solver value will be examined to verify that the the optimal cutoff value maximizes the Sharpe ratio. If multiple cutoff values return the same maximum value for the Sharpe ratio, then the smallest value is chosen as the optimal. This is done to ensure that the strategy is reactive enough also in the future, and thus the strategies constructed in this thesis can be seen as more risk-seeking. The optimal cutoff values and the corresponding Sharpe ratios for each strategy are listed in Table 3.

Equity index	Cutoff value	Sharpe ratio
SSE	0.16	0.5252
DAX	0.23	0.6596
CAC40	0.16	0.7247
Nikkei225	0.01	0.7734
MOEX	0.25	0.4702
S&P 500	1.25	1.1202

Table 3: Optimal cutoff values for the change in the GPR index and the corresponding Sharpe ratios

For China, the SSE index is used to construct the strategy with a skipping period of 1. The maximum Sharpe ratio for the strategy is 0.5252, and the smallest corresponding cutoff value is 0.16. Therefore the strategy constructed for China will short the SSE index in month t if the change in the GPR index between months $t-2$ and $t-1$ is at least 0.16.

For Germany the main equity index is DAX and the strategy is constructed by using a skipping period of 2. The cutoff value of 0.23 is the smallest cutoff value that returns the largest Sharpe ratio. Thus, in the strategy constructed for Germany changes in the GPR index which are at least 0.23 between months $t-1$ and t will trigger the strategy to short the equity index in month $t+2$.

The CAC40 index is used as the main equity index for France and the strategy is also constructed using a skipping period of 2. The cutoff value 0.16 returns the largest Sharpe ratio, and therefore this value will be used in the strategy constructed for France. This means that the changes in the GPR index which are at least 0.16 between months $t-1$ and t, will result in shorting the index in month $t+2$. The cutoff values for China, Germany, and France are in the same range, which is expected as the upper and lower quartiles are in the same range, as can be observed in Figure 8.

For Japan, a skipping period of 1 is used in the constructed strategy for the Nikkei225 index. The cutoff value of 0.01 corresponds to the largest Sharpe ratio. Thus, in the strategy constructed for Japan the strategy shorts the equity index in month t if the change in the GPR index between months $t-2$ and $t-1$ is at least 0.01. The optimal cutoff value is significantly smaller compared to the other three countries already studied, which is expected as the upper and lower quartiles are very close to each other for Japan. Thus, in Japan also small changes in the geopolitical tension affect the market and therefore the strategy reacts to even slight changes in the GPR index.

For Russia, the MOEX index is used to construct the strategy with a skipping period of 1. The cutoff value 0.25 results in the largest Sharpe Ratio, and thus this value is used to construct the strategy. This means that the strategy shorts the equity index in month t if the change in the GPR index is at least 0.25 between months $t-2$ and $t-1$. Even though the maximum and minimum values for the change in the GPR index have the largest absolute values in Russia compared to the other countries, the upper and lower quartiles are just slightly larger compared to Germany, France, and China. Therefore the optimal cutoff value is slightly larger in Russia compared to Germany, France, and China, but still in the same range. This means that even though the GPR index can fluctuate significantly in Russia, the market also reacts to smaller changes, and therefore the market is reactive when it comes to geopolitical tensions in Russia.

Finally, for the United States, the strategy is constructed with a skipping period of 2 for the S&P 500 index. The cutoff value of 1.25 is the smallest cutoff value that maximizes the Sharpe Ratio value, and therefore this value is used in the strategy. In other words, the strategy shorts the index in month t if the change in GPR index is at least 1.25 between months $t-3$ and $t-2$. The optimal cutoff value for the United States is significantly larger compared to the optimal cutoff values in the other five countries. This is expected since the upper and lower quartiles in the change in the GPR index in the United States have the largest absolute values compared to the other countries in Figure 8.

Using a larger cutoff value means that the market does not react to slight changes in the geopolitical tension, but rather only to significant changes. This may be due to the stocks and their industries that are traded in the equity index, and how affected they are by the local geopolitical tension. For example, the stocks traded in the S&P 500 index may be operating more globally and in industries that are thriving also in geopolitically uncertain times, and therefore the returns of the index are not affected by small changes in the geopolitical tension in the United States. In addition, as the United States is often involved in other countries' geopolitical tensions, for example by aiding countries in war or under other threats, the GPR index for the United States may be increased even though the conflict is not happening in their country or affecting it directly. This may happen since the GPR index is increased if the words associated with geopolitical tension and the country's name or its main cities are mentioned in the same article. Thus the specific geopolitical events increasing the GPR index should be investigated further to see how they are affecting the country in question. These effects of the industry allocations in the equity index as well as the specific geopolitical events will be further investigated in Section 8.

To conclude the strategies will be constructed for the main equity indices of six different countries with the optimal cutoff values and skipping periods as stated in Table 4.

Country	Equity index	Skipping period	Cutoff value
China	SSE	1	0.16
Germany	DAX	2	0.23
France	CAC40	2	0.16
Japan	Nikkei225	1	0.01
Russia	MOEX	1	0.25
The United States	S&P 500	2	1.25

Table 4: Main equity indices, cutoff values, and skipping periods (in months) used in the strategy construction for the six different countries

5.4 Strategy algorithm

The monthly returns for each strategy are calculated with a simple algorithm. Because the strategy is constructed individually for each equity index, the portfolio in each strategy consists of the main equity index. At the beginning of each month, the equity index is either bought or shorted, and therefore the portfolio is either short or long all the time, and 100 percent of the portfolio is invested in the strategy each month. Trading costs are neglected when constructing the strategy.

Let $R_{e,t}$ be the monthly return of the equity index in month t, t_s the skipping period, c the cutoff value, and $\Delta GPR_{t,t-1}$ the change in the country-specific GPR index between month $t-1$ and month t. Calculating the monthly return for the strategy in month t, which is defined as $R_{p,t}$, is shown in Algorithm 1.

Algorithm 1 Monthly return for the strategy

initalise. skipping period t_s, cutoff value c, month t:
if $\Delta GPR_{t,t-1} > c$ **then**
    $R_{p,t+t_s} = -R_{e,t+t_s}$
else
    $R_{p,t+t_s} = R_{e,t+t_s}$
end if
end

The algorithm first sets the values for the skipping period and the cutoff values, which are determined in Sections 5.2 and 5.3.1. If the change in the country-specific GPR index between the last month $(t-1)$ and the current month (t) is larger than the cutoff value, then the strategy shorts the equity index after the skipping period. When the equity index is shorted in month $t+t_s$, the monthly return for the strategy is equal to the equity index monthly return multiplied by -1. In general, when an investor opens a short position, they borrow the shares, sell them at the market price, and then hope for the price to fall so that they can repurchase the shares later on and return them to the lender of the shares. In this thesis, interests and trading costs are disregarded, and thus the return when shorting is equal to the negative value of the monthly return of the equity index. This is the profit (or loss) that is gained from the short position. Thus in Algorithm 1, if the monthly return in the equity index is negative, meaning that the price falls during the month, then shorting the equity index

will result in a positive monthly return for the strategy which is equal to the absolute value of the monthly return in the equity index. If the change in the country-specific GPR index is equal to or below the cutoff value, then the strategy buys the index after the skipping period. This means that the return for the strategy in month $t + t_s$ is equal to the monthly return of the equity index in month $t + t_s$. Algorithm 1 illustrates how the returns are calculated for one month, and this is repeated each month by changing the value t. Each position is held for a month, after which a new position is chosen based on the change in the GPR index, and thus there are no overlapping positions.

6 Country-specific strategy results

In this section, the strategies are constructed using the main equity indices of China, Germany, France, Japan, Russia, and the United States. The strategy's performance is calculated using the Sharpe ratio and compared to the performance of the equity index in each country.

6.1 China

For China, the strategy is constructed with a one-month skipping period and a cutoff value of 0.16 for the change in the GPR index. Due to the use of a skipping period, the strategy starts to generate returns on 3/2010, and therefore when comparing the returns of the equity index and the strategy, both of these returns are indexed at 1 on 2/2010. For China, the SSE Composite Index is used as the main equity index to construct the strategy.

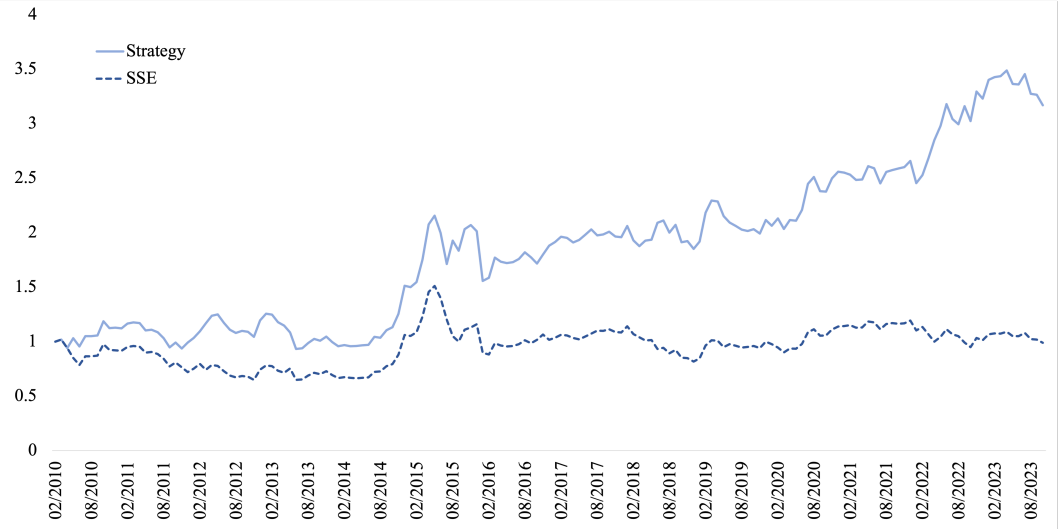

Figure 9: Returns of the constructed strategy for China and the SSE Composite index. Returns are indexed at 1 on 2/2010.

Figure 9 illustrates the monthly returns of the constructed strategy and the SSE Composite index between 2/2010 and 10/2023. The index value of the strategy during the sample period is above the value of the SSE Composite index. It also seems that most of the time the strategy is able to correctly predict the movements in the equity index. This means that a correct prediction is made when the assumption that increasing GPR results in decreasing returns (and vice versa) is satisfied. In more detail, a prediction is considered correct if the change in the GPR index is larger than the predefined cutoff value and this is followed by decreasing returns in the main equity index after a specified skipping period. Similarly, if the change in the GPR index is smaller than the cutoff value, the prediction is defined as correct if it is followed by increasing returns in the main equity index after the skipping period. For example, at the beginning of 2010 the returns of the SSE index decrease while the returns

of the strategy increase, which suggests that the strategy is able to short the index successfully based on the change in the GPR index. At the beginning of 2017 the returns of the strategy increase, as the returns of the SSE index remain stable, which means that the strategy is able to predict the future movements of the equity index based on the change in the GPR index. Also, in 2022 the strategy returns increase significantly as the returns of the SSE index decrease slightly, and thus the strategy is again able to short the index successfully. The Sharpe ratio and final index value of the strategy and the SSE index are compared in Table 5. In addition, the table includes the share of correct predictions from all the predictions made by the strategy.

	Final index value	**Sharpe ratio**	**% of correct predictions**
Strategy	3.17	0.53	56.10 %
SSE	0.99	0.10	

Table 5: The final index value and the Sharpe ratio of the constructed strategy and the SSE Composite index. The % of correct prediction is the share of predictions where the strategy correctly predicts the movement of the equity index based on the change in the GPR index from all the predictions made.

From Table 5 it can be observed that the Sharpe ratio for the strategy is significantly better compared to the Sharpe ratio of the SSE index. This is also seen in the final index value, as the strategy's final index value is 2.18 units higher. The strategy is able to predict the movement correctly for the majority of the time, with 56.10% of correct predictions out of all predictions. For China, the momentum strategy based on the change in the GPR index seems to work well and beats the index between the period of 2/2010 and 10/2023.

6.2 Germany

For Germany the strategy is constructed with a skipping period of 2 months and a cutoff value of 0.23 is used for the change in the GPR index. The first return of the strategy is generated on 4/2010, due to the use of the 2-month skipping period, and thus the returns of the main equity index and the strategy are indexed at 1 on 3/2010. The DAX index is used as the main equity index for Germany.

The monthly returns of the constructed strategy and the DAX index between 3/2010 and 10/2023 are illustrated in Figure 10. For the first 4 years, the returns of the strategy and the DAX index are identical, which means that the changes in the GPR index are always below 0.23 in this period, and therefore the strategy merely buys the index every month. In general, if the equity index returns increase gradually, there have not been significant increases in the GPR index, and therefore the strategy often follows the equity index. In 2014 the strategy index value is below the DAX index value, which suggests that the strategy has made incorrect predictions about the movement of the equity index. At the beginning of 2016, the DAX index returns decrease, while the strategy returns increase, which means that during this time the strategy is able to correctly predict the movement of the equity index. Also at the beginning of 2020

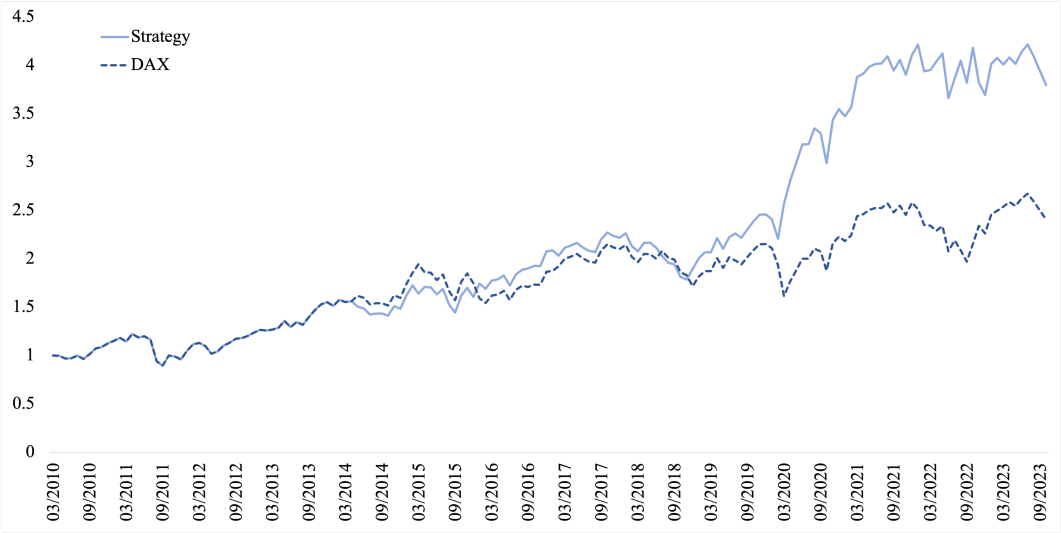

Figure 10: Returns of the constructed strategy for Germany and the DAX index. Returns are indexed at 1 on 3/2010.

the strategy first decreases as the DAX index decreases as well, but after a couple of months, the strategy is able to correctly short the index, which leads to a significant increase in the strategy.

	Final index value	Sharpe ratio	% of correct predictions
Strategy	3.80	0.66	60.12 %
DAX	2.41	0.50	

Table 6: The final index value and the Sharpe ratio of the constructed strategy and the DAX index. The % of correct prediction is the share of predictions where the strategy correctly predicts the movement of the equity index based on the change in the GPR index from all the predictions made.

Table 6 includes the Sharpe ratios and the final index values of the strategy and the DAX index, as well as the percentage of correct predictions made by the strategy. The Sharpe ratio as well as the final index value are higher for the strategy compared to the DAX index. The strategy is also able to correctly predict the movement of the DAX index for the majority of the time, with 60.12% of correct predictions out of all the predictions. As the strategy is best at predicting large decreases in the equity index, and for the DAX index, the first larger decrease happens at the beginning of 2020, the strategy increases significantly only after this point. Thus, there is not as large a difference between the Sharpe ratios as there were in the case of China, even though the share of correct predictions is larger for Germany.

6.3 France

For France, the strategy is constructed using CAC40 index as the main equity index with a skipping period of 2 months and a cutoff value of 0.16. The first returns of

the strategy are on 4/2010, and therefore in order to compare the index returns of the strategy and the CAC40 index, both of the index returns are indexed at 1 at time point 3/2010.

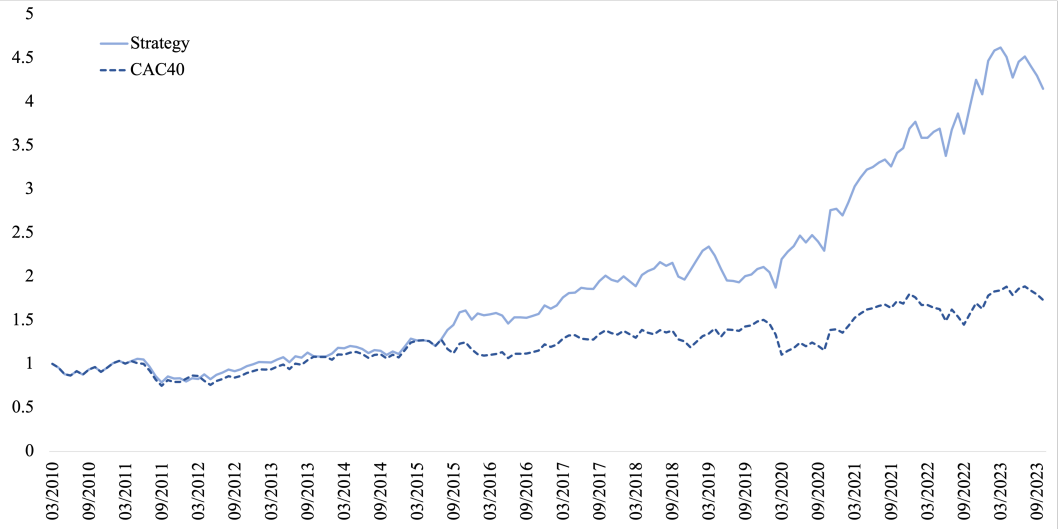

Figure 11: Returns of the constructed strategy for France and the CAC40 index. Returns are indexed at 1 on 3/2010.

Figure 11 illustrates the monthly returns of the strategy and the CAC40 index between 3/2010 and 10/2023. For the first year, the strategy follows the CAC40 index, as the increases in the GPR index are below the cutoff value of 0.16. From 2011 to the beginning of 2015 the index value of the strategy returns is slightly above the CAC40 index value, as the strategy is able to correctly predict a few slight decreases in the CAC40 index. During 2015 the strategy correctly predicts couple months where the returns of the CAC40 index are negative, and therefore the returns of the strategy are larger compared to the returns of the equity index. After 2020 the same trend happens as in the case of Germany, where the strategy is able to predict some of the decreases in the equity index, which results in the increase of the strategy's returns. In general, it seems that as the equity index returns start to decrease, also the strategy returns decrease initially, but then after couple months the strategy is able to predict the decrease correctly which results in increasing returns for the strategy. For the last three years in the examined period the strategy correctly predicts the movements of the equity index for the majority of the time, which results in a larger deviation between the index values of the strategy and the CAC40 index. The performance of the CAC40 index and the strategy are in Table 7.

Table 7 includes the final index value and the Sharpe ratio of the CAC40 index and the constructed strategy, as well as the percentage of the correct predictions from all the predictions made by the strategy. Again, the final index value and the Sharpe ratio are significantly larger compared to the CAC40 index, which suggests that the strategy is performing well. Also, as the 57.67 % of the predictions are correct, the strategy works as expected for the majority of the time.

	Final index value	Sharpe ratio	% of correct predictions
Strategy	4.15	0.72	57.67 %
CAC40	1.73	0.36	

Table 7: The final index value and the Sharpe ratio of the constructed strategy and the CAC40 index. The % of correct prediction is the share of predictions where the strategy correctly predicts the movement of the equity index based on the change in the GPR index from all the predictions made.

6.4 Japan

For Japan, the constructed strategy uses a skipping period of 1 month and a cutoff value of 0.01. The Nikkei225 index is used as the main equity index. Due to the use of skipping periods, the first return generated by the strategy is on 3/2010, and thus the returns of the Nikkei225 index and the strategy are indexed at 1 on 2/2010.

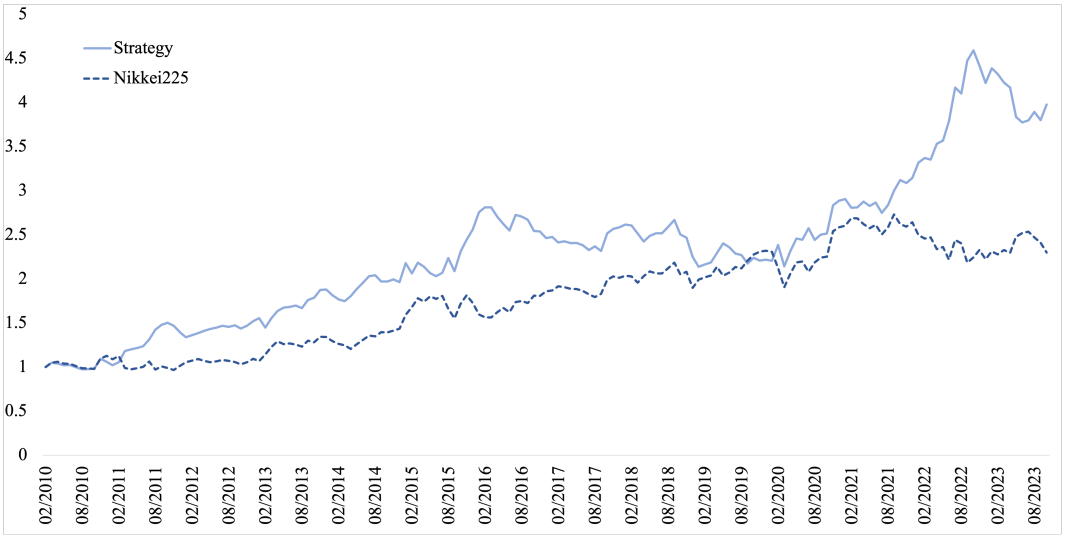

Figure 12: Returns of the constructed strategy for Japan and the Nikkei225 index. Returns are indexed at 1 on 2/2010.

The monthly returns of the strategy and the Nikkei225 index between 2/2010 and 10/2023 are illustrated in Figure 12. At the beginning of the studied period, the strategy follows the equity index with the exception of incorrect predictions at the end of 2010, resulting in a slight decrease in the index value of the strategy's returns. At the beginning of 2011, the strategy correctly predicts the decrease in the equity index which increases the strategy returns. From 2012 to 2015 the strategy makes few incorrect predictions but all in all the strategy index value stays above the Nikkei225 index value. At the end of 2015, the strategy correctly predicts a more significant decrease in the equity index, which results in positive strategy returns, but then from the end of 2016, the strategy returns become negative, which suggests that the strategy incorrectly predicts the movement of the equity index. From the end of 2021, the strategy index value increases significantly as the value of the Nikkei225

index decreases due to large increases in the GPR index. Again, at the end of the studied period, the strategy returns become negative, which suggests that the GPR index increased but the market did not react to this in the assumed way, which results in false predictions made by the strategy. Thus not all increases in the GPR index result in the decrease of the equity index, and the effect of the GPR change on the returns is dependent on the nature of the event as well as the stocks in the equity index. The performance measures of the strategy and the Nikkei225 index are illustrated in Table 8.

	Final index value	Sharpe ratio	% of correct predictions
Strategy	3.98	0.77	57.93 %
Nikkei225	2.30	0.49	

Table 8: The final index value and the Sharpe ratio of the constructed strategy and the Nikkei225 index. The % of correct prediction is the share of predictions where the strategy correctly predicts the movement of the equity index based on the change in the GPR index from all the predictions made.

From Table 8 it can be seen that the strategy outperforms the Nikkei225 index, with a larger Sharpe ratio and final index value. The strategy correctly predicts 57.93 % of the index movements, and therefore for the majority of the time the strategy works as expected and follows the equity index when the returns are positive or shorts the index as negative returns occur.

6.5 Russia

The MOEX index is used to construct the strategy for Russia, with a skipping period of 1 month and a cutoff value of 0.25 for the change in the GPR index. The first returns in the strategy are generated on 3/2010, and therefore to compare the returns of the MOEX index and the strategy, both of these returns are indexed at 1 on 2/2010.

Figure 13 illustrates the monthly returns of the MOEX index and the constructed strategy between 2/2010 and 10/2023. The strategy follows the equity index quite closely for the first five years since for the majority of the time the change in the GPR index remains below the cutoff value of 0.25. At the beginning of 2015, the strategy correctly predicts the decrease in the equity index, and therefore the returns are positive. The most significant increase in the strategy index value occurs at the beginning of 2022 as the GPR index increases significantly, which results in a decrease in the MOEX index. After the spikes in the strategy index value during 2022, the index value decreases significantly. During this time, the strategy predicts the movement of the equity index incorrectly which is most likely due to the fact that, as illustrated in Figure 5, during this time the MOEX index fluctuates a lot, and due to the use of skipping periods the strategy is not able to react to these changes quickly enough. This results in negative returns in the strategy at the end of 2022, due to the large fluctuations in the MOEX index and the strategy's inability to anticipate these fluctuations efficiently enough. The performance measures of the constructed strategy and the MOEX index are in Table 9.

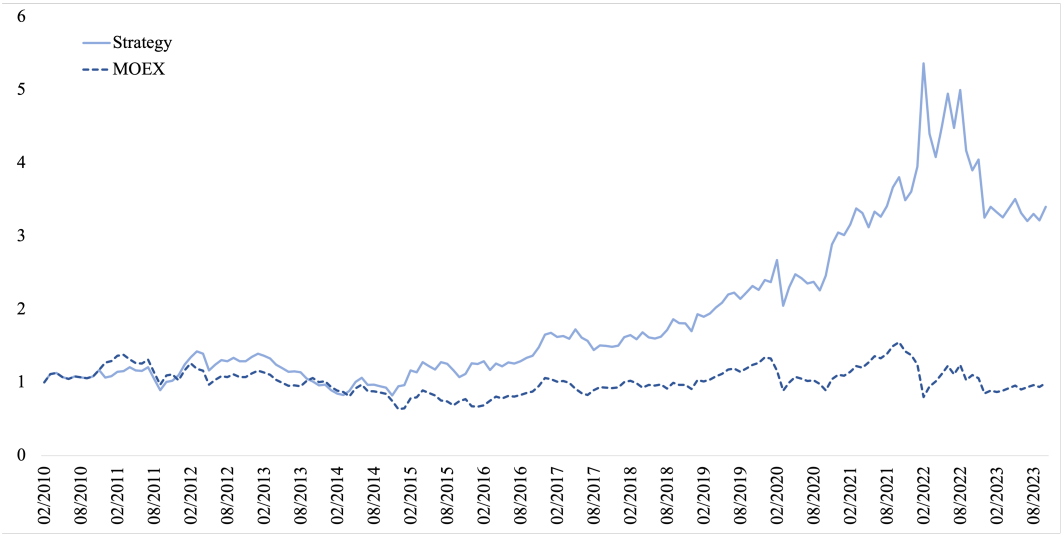

Figure 13: Returns of the constructed strategy for Russia and the MOEX index. Returns are indexed at 1 on 2/2010.

	Final index value	Sharpe ratio	% of correct predictions
Strategy	3.40	0.47	53.05 %
MOEX	0.99	0.14	

Table 9: The final index value and the Sharpe ratio of the constructed strategy and the MOEX index. The % of correct prediction is the share of predictions where the strategy correctly predicts the movement of the equity index based on the change in the GPR index from all the predictions made.

From Table 9 it can be seen that the strategy performs well compared to the MOEX index, as the final index value and the Sharpe ratio are larger. The strategy is again able to correctly predict the movements of the equity index for the majority of the time, with 53.05% of predictions made correctly. This percentage is slightly smaller compared to the percentages observed in other countries. Overall the MOEX returns fluctuates a lot during the whole study period compared to the other countries, and this may result in more false predictions throughout the study period due to the fact that the strategy is not able to react to frequent fluctuations due to the skipping period, which explains the lower percentage of correct predictions. Thus if the equity index fluctuates significantly the momentum strategy based on the change in the GPR index with a skipping period may not be efficient enough.

6.6 The United States

For the United States, the strategy is constructed with a 2-month skipping period and a cutoff value of 1.25 for the change in the GPR index. The S&P 500 index is used to construct the strategy. The first returns generated by the strategy are on 4/2010, and therefore to compare the returns the equity index returns and the strategy returns are

indexed at 1 on 3/2010.

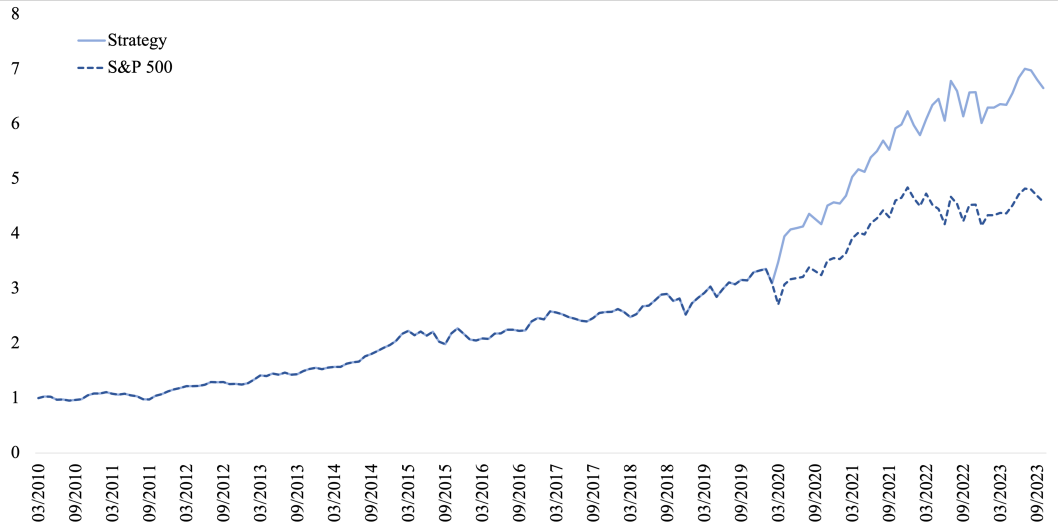

Figure 14: Returns of the constructed strategy for the United States and the S&P 500 index. Returns are indexed at 1 on 3/2010.

Figure 14 illustrates the monthly returns of the strategy and the S&P 500 index between 3/2010 and 10/2023. The strategy follows the equity index until the beginning of 2020, which means that for the first 10 years, there are no changes in the GPR index that would exceed the set cutoff value of 1.25. Since in these ten years, the equity index is increasing steadily, the strategy should not sell the index short, as the index value for the strategy would most likely then decrease below the equity index value, and thus investing in the equity index is the optimal choice. At the beginning of 2020, the strategy is able to correctly predict the movement of the equity index with a slight lag, and thus the strategy index value increases above the S&P 500 index value. After this, the strategy again follows the movements of the equity index, with the exception of predicting correctly the decrease in S&P 500 on 3/2022, which results in positive strategy returns as the equity index decreases. The performance measures of the strategy and the S&P 500 index are in Table 10.

	Final index value	Sharpe ratio	% of correct predictions
Strategy	6.65	1.12	65.03 %
S&P 500	4.58	0.93	

Table 10: The final index value and the Sharpe ratio of the constructed strategy and the S&P 500 index. The % of correct prediction is the share of predictions where the strategy correctly predicts the movement of the equity index based on the change in the GPR index from all the predictions made.

From Table 10, it can be seen that the Sharpe ratio and the final index value are larger for the strategy compared to the S&P 500 index. As the S&P 500 index has performed very well itself over the last 13 years, the difference between these

performance measures is not as significant compared to the other countries. Therefore for the strategy to outperform the index, there should be some significant decreases in the equity index, which the strategy is able to detect. In addition, as mentioned before, the change should not last for a long time, because the market often loses interest in a specific geopolitical tension at some point after which investors do not react to it anymore, resulting in incorrect predictions in the strategy.

7 Sensitivity analysis

Sensitivity analysis is performed to evaluate the robustness of the constructed strategies and their performance. The analysis is done by dividing the original data sample into training data and test data. The training data is used to construct the skipping periods and cutoff values used in the strategies, and the test data is used to test the performance of the strategy using the parameters determined with the training data. The training data includes the main equity index returns and the changes in the country-specific GPR indices from January 2010 to December 2019. The test data includes the data from January 2020 to October 2023.

To determine the skipping periods for the training data, the correlations with different lags between the main equity index returns and change in the GPR index will be calculated for each country, similarly as in Section 5.2.

	ΔGPR(t,t-1) CHN	ΔGPR(t,t-1) DEU	ΔGPR(t,t-1) FRA	ΔGPR(t,t-1) JPN	ΔGPR(t,t-1) RUS	ΔGPR(t,t-1) USA
Equity index return (t)	-0.06	0.01	0.13	-0.17	0.05	-0.09
Equity index return (t+1)	-0.01	0.08	0.00	**-0.03**	-0.07	0.08
Equity index return (t+2)	-0.01	**-0.03**	**-0.06**	0.05	0.20	-0.03
Equity index return (t+3)	**-0.09**	0.03	0.00	0.17	-0.02	0.07
Equity index return (t+4)	0.05	0.10	0.05	-0.02	**-0.08**	**-0.05**

Table 11: Correlations between monthly changes in country-specific GPR indices and the returns of country-specific equity indices with different lags, using the training data. In the table, t denotes the current month, and $t+1$ to $t+4$ denotes the following months. Here *Equity index return* denotes the returns of country-specific equity indices explained in Section 4.1. $\Delta GPR(t, t-1)$ is the change in the country-specific GPR index between the month $t-1$ and the month t. Highlighted cells are the negative correlations with the largest absolute values, which determine the optimal skipping periods.

Table 11 includes the correlations between monthly changes in country-specific GPR indices and the returns of country-specific equity indices with different lags, using the training data. These values can be compared to the parameter values constructed from the entire data, which are in Table 4. The skipping periods for Germany, France, and Japan remain the same, but the correlation is not as strong in the case of Germany and Japan. For China, the skipping period increases from one month to three months. For Russia, the skipping period increases from one month to four months, while for the US, the skipping period increases from two months to four months.

The cutoff values are then determined for the training data using the above-mentioned skipping periods, by maximizing the Sharpe ratio for the strategy. The skipping periods and cutoff values constructed from the training data are in Table 12.

These cutoff values can be compared to the cutoff values determined from the entire data, which are in Table 4. The cutoff values for France and the United States remain the same. For Russia and Japan, the cutoff values increase, which indicates that during the training period, these strategies are not as reactive to changes in geopolitical risk compared to the original strategy. For China and Germany, the cutoff values decrease, which means that during the training period, the strategy is more sensitive to

Country	Equity index	Skipping period	Cutoff value
China	SSE	3	0.09
Germany	DAX	2	0.15
France	CAC40	2	0.16
Japan	Nikkei225	1	0.18
Russia	MOEX	4	0.68
The United States	S&P 500	4	1.25

Table 12: Main equity indices, cutoff values, and skipping periods (in months) constructed from the training set

changes in geopolitical risk compared to the original strategy. To conclude, it seems that the construction of the strategy parameters is sensitive to the data they are derived from. Thus, the parameters should be updated constantly as new data on the returns and GPR index becomes available, rather than using parameters that are determined using past data.

The performances of the strategies constructed with the parameters derived from the training data are evaluated with the test data. The returns of the strategies are compared to the returns of the main equity indices. The results from implementing the strategy into the test data are in Table 13.

	Final index value	Sharpe ratio	% of correct predictions
Strategy CHN	0.59	-0.92	49.38 %
SSE	0.99	0.05	
Strategy DEU	1.49	0.61	63.04 %
DAX	1.12	0.24	
Strategy FRA	1.97	0.98	63.04 %
CAC40	1.15	0.28	
Strategy JPN	1.44	0.66	56.52 %
Nikkei225	0.99	0.07	
Strategy RUS	0.59	-0.19	52.17 %
MOEX	0.74	-0.03	
Strategy USA	1.15	0.29	56.52 %
S&P 500	1.38	0.56	

Table 13: The final index value, Sharpe ratio, and percentage of correct predictions of the constructed strategies and the main equity indices using the test data. The returns are indexed at 1 on 12/2019.

From Table 13 it can be seen that the performance of the strategy varies depending on the country. For the countries with a larger skipping period, the final index value and Shape ratio are lower compared to corresponding values from the equity index. For the strategies using skipping periods of 1 or 2 months, the strategy performs well, in the sense that the final index value and Shape ratio are higher compared to the corresponding equity index values. Thus, using a large skipping period might not be a sensible choice for the strategy, as it takes too long for the strategy to react to geopolitical risks. In these cases, the strategy makes investment decisions based on changes in geopolitical tensions that occurred three or four months ago, during which the equity indices most likely have reacted to these events already. Therefore

in future development of the model, the skipping period could be limited to two months, and the correlation between the equity index returns and GPR index changes would determine whether a skipping period of one month or two months is used. This way, the strategy would more likely remain reactive enough to efficiently exploit the assumed relationship between returns and geopolitical risks.

The Sharpe ratios are lower for each strategy, except for France, compared to the Sharpe ratios calculated for the original strategies which used the entire data to construct the parameters. Because the parameter values represent the market's attitude towards geopolitical risks, and this constantly changes, using parameter values from the past might not represent the behavior of the current market correctly. For France, the skipping period and cutoff value are the same for the training data and the entire data, and in this case, the Sharpe ratio is higher for the test data compared to the ratio of the original strategy.

The strategy presented in this thesis provides an algorithm that could be used in the future, but in order for the strategy to perform well, it seems that parameter values need to be updated constantly as new data becomes available. This means that as new data becomes available, it should be added to the data, and the entire data should be used to determine new parameter values, rather than using the values presented in Section 5. This way, the parameter values would include the market's current behavior in addition to historical behavior, and therefore investment decisions would be made based on all the information available.

8 Explorative analysis

8.1 Industry analysis

To better understand how the change in the GPR index affects the returns of the equity indices, the effect between different industry stocks and the GPR index should be studied. To do this, the results constructed by Caldara and Iacoviello (2022) to measure exposures of different industries to change in the GPR index, are examined. Then, the industries in the six main equity indices are investigated, to understand how exposed they are to changes in geopolitical risk, which can better explain the results attained in Section 6. Caldara and Iacoviello (2022) investigate the exposure of different industries to the change in the GPR index. The exposure is calculated by regressing daily portfolio returns in the 49 industry groups of Fama and French (1997) on changes in the daily GPR index. Therefore the regression equation used by Caldara and Iacoviello (2022) to calculate the exposure is the following:

$$R_{k,t} = \alpha_k + \beta_k \Delta GPR_t + \epsilon_{k,t}, \tag{3}$$

where $R_{k,t}$ is the annualized daily excess return in industry k over the one-month Treasury bill rate and ΔGPR_t is the change in the daily GPR index. Then β_k coefficients are estimated and demeaned and the signs are changed so that positive values indicate high exposure. These results are replicated from the study made by Caldara and Iacoviello (2022), using the replication data from Caldara and Iacoviello (2021). These results are in Figure 15.

In Figure 15 higher values indicate a larger decline in industry daily stock returns after an increase in the daily GPR index, and vice versa. For example, returns of stocks in the industrial metal mining industry increase as the GPR index increases, while the stocks in the shipping contained industry decrease as the GPR index increases. Therefore, equity indices including stocks from industries that are exposed to changes in the GPR index, are expected to decrease more significantly as the GPR index increases, while equity indices with stocks from industries with negative exposure are expected to increase as the GPR index increases. Thus, the main industries of the stocks in each of the six equity indices used to construct the strategies in this thesis should be investigated, as the strategies assume that the equity index returns should decrease with increasing GPR index.

Figure 16 illustrates the sector weights in the SSE Composite Index. From Figure 16 it can be seen that companies operating in the Financials, Real Estate as well as Industrials total to almost half of the market capitalization of the index. According to MSCI (2006), the Industrials Sector includes distributors and manufacturers of capital goods such as aerospace and defense, building products, electrical equipment and machinery, and companies that offer engineering and constructing services. The average exposure of the industries belonging to the Industrial sector according to Figure 15 is 0.6, and therefore the returns on this sector are also negatively impacted if the GPR index increases. Also, as the real estate and banking industries have positive exposure to the GPR index, increasing geopolitical tensions decrease the returns in these sectors. Hence, as the largest sectors in the SSE Composite index are expected to

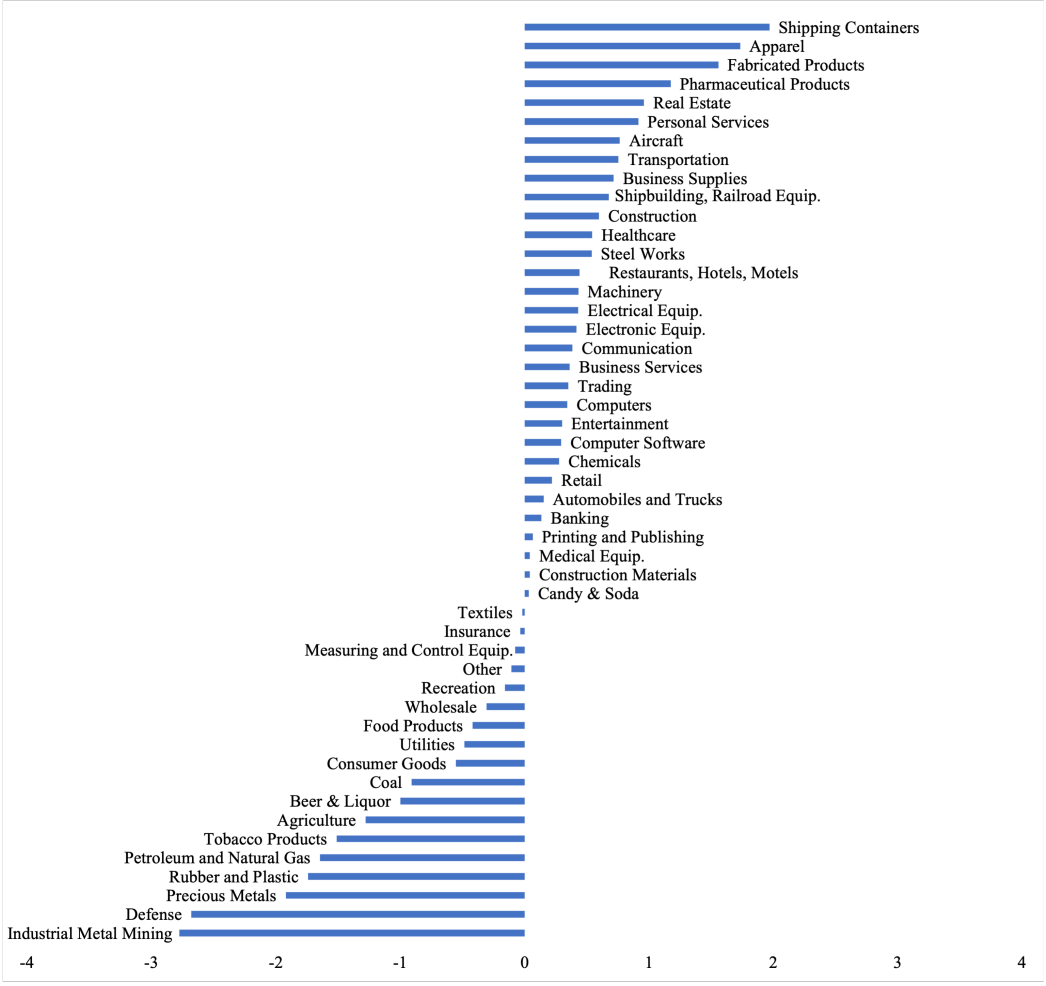

Figure 15: Average exposure to change in the GPR index for different industries (Caldara and Iacoviello, 2021). Values are estimated on a sample from 1985 to 2019, which are standardized to have zero mean and unit standard deviation.

decrease as the GPR index increases, the strategy should work as expected. Because the smaller sectors in the SSE Composite index, for example, Utilities, are negatively exposed to the GPR index, the strategy will ultimately make false predictions some of the time.

Figure 17 illustrates the sector allocations in the DAX index. The largest two sectors are Others and Industrials. From Figure 15 it can be seen that the Others sector is negatively exposed to the GPR index, with a value of -0.11. As mentioned before, the Industrials sector is positively exposed to the GPR index with a value of 0.6. Therefore even though the Others sector is slightly larger than the Industrials sector, the exposure is not as significant, and therefore the largest sectors combined are more likely positively exposed to the GPR index. In addition, the Insurance sector has slight negative exposure to the GPR index, but the Automobile, Software, and Healthcare sectors have more significant positive exposures to the GPR index, and thus all in all the index seems to be positively exposed to the GPR index. This means that for the

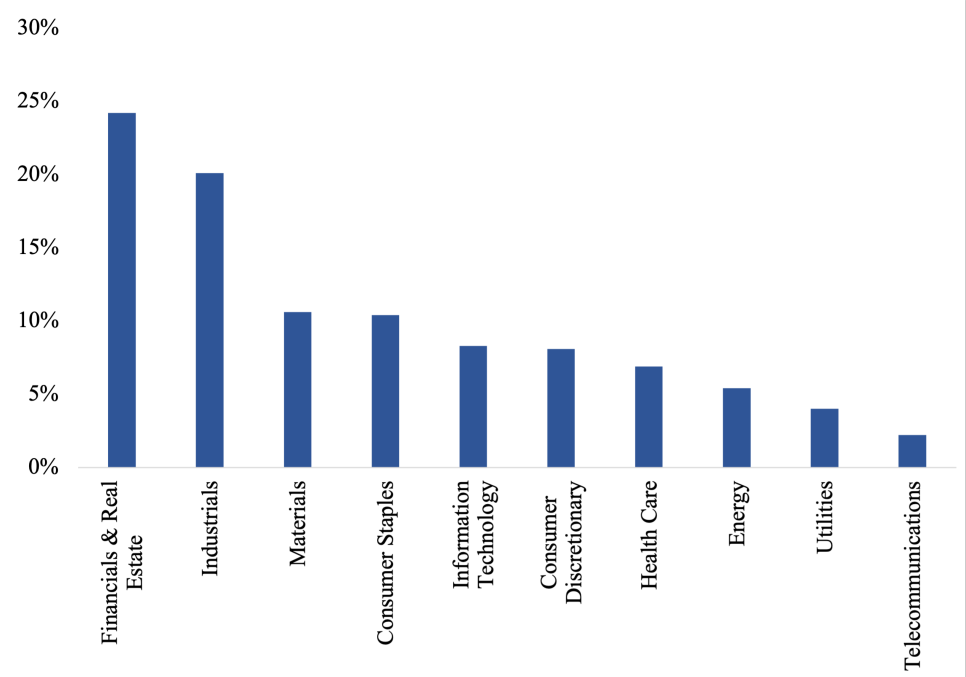

Figure 16: SSE sector allocations as of December, 2021 (Research, 2021).

majority of time, the strategy should work as expected, meaning that increasing GPR index results in decreasing returns in the equity index.

Figure 18 illustrates the sector allocation of the CAC40 index. Consumer Discretionary and Industrials are the largest sectors. According to MSCI (2006) the Consumer Discretionary sector has a manufacturing segment and service segment. The manufacturing segment includes automotive, household durable goods, leisure equipment, textiles, and apparel. The services segment includes restaurants, hotels, and other leisure facilities, media production and services, and consumer retailing and services. The exposure of the Consumer Discretionary sector can be calculated from Figure 15 by calculating the average of all the industries belonging to the sector in question. The average exposure of the Consumer Discretionary sector is 0.26, and therefore as the GPR index increases the returns of stocks operating in the Consumer Discretionary sector are expected to decrease. As the Industrials sector has an exposure of 0.6, the largest sectors in the CAC40 index are expected to decrease as the GPR index increases, and therefore the strategy constructed for the CAC40 index is expected to work for the majority of time. It is worth mentioning that the Energy sector is also quite large in the CAC40 index, which has negative exposure to the GPR index, and therefore the Energy sector can increase in returns as the GPR index increases, which can result in false predictions in the strategy.

In Figure 19, the sector allocation of the Nikkei225 index is illustrated. From Figure 19 it can be seen that Technology and Consumer Goods are the two largest sectors, with the Technology sector contributing to almost half of the market capitalization of the index. If the assumption is that the Technology sector includes the Computer Software, Computers, and Electronic Equipment sectors from Figure 15, then the

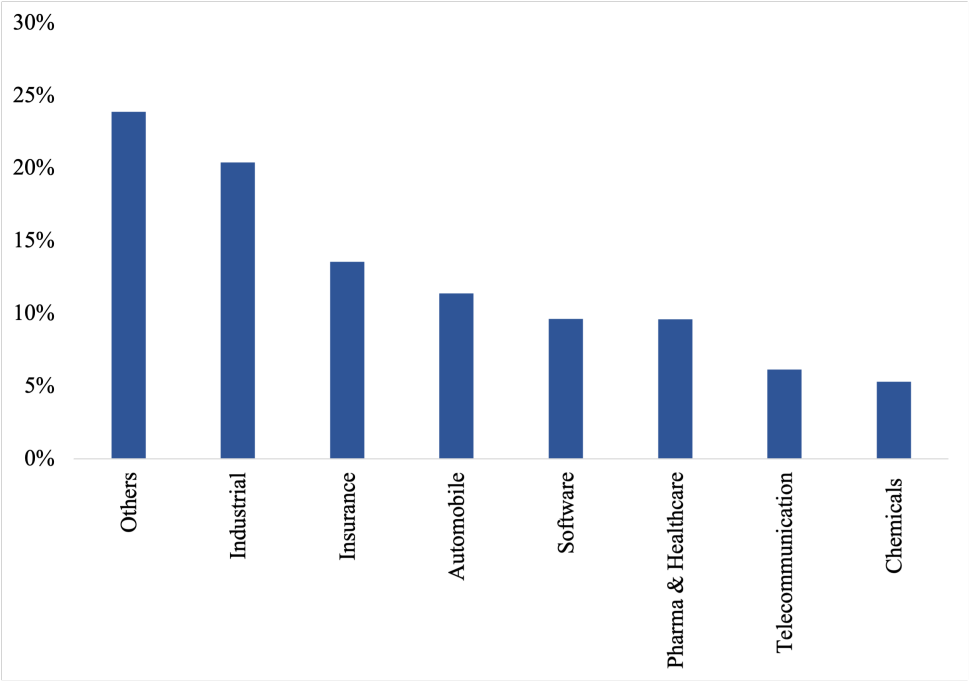

Figure 17: DAX sector allocation as of September, 2023 (Quontigo, 2023).

Technology sector has an exposure of 0.35 to the GPR index. Thus, almost half of the stocks in the Nikkei225 index are expected to decrease in returns as the GPR index increases. On the other hand, the Consumer Goods sector has negative exposure in Figure 15, and therefore the strategy can also make false predictions from time to time. In general, it seems that the majority of the industries of the stocks in the Nikkei225 index have positive exposure, and thus the strategy should work as expected for the majority of the time.

Figure 20 illustrates the asset allocations of the MOEX index. The energy sector is the largest sector, accounting for 40 percent of the market capitalization in the MOEX index. The Metals and mining sector is the third largest sector. Both the Energy sector and the Metals and mining sector are negatively exposed to the GPR index according to Figure 15, and therefore the index returns should increase as the GPR index increases, which means that the strategy should not work. In Section 6.5 it was seen that the strategy constructed for the MOEX index worked, and performed better than the index, and thus it seems that the geopolitical tensions have affected the other sectors in the index more significantly. For example, the geopolitical tensions may have affected the Finanacials and Technology sector more, which are positively exposed to the GPR index. In addition, the geopolitical tensions in Russia have been very severe after the Ukraine invasion, and therefore the expected exposures to the different industries may be false, as the sanctions for Russia may have affected some industries more severely than expected. For example, as Russia started its attack on Ukraine in February 2022, the MOEX index decreased significantly (Q.ai, 2022), despite the large allocation to the Energy sector. The MOEX index lost a third of its value after the invasion because of the Western sanctions and divestments from the Russian economy

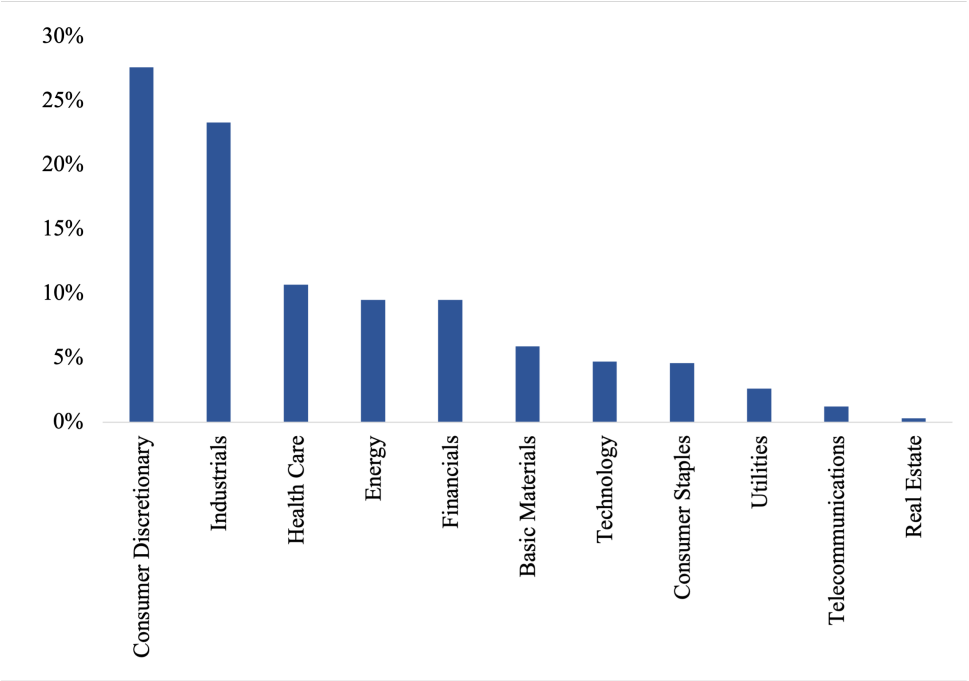

Figure 18: CAC40 sector allocation as of September, 2023 (Euronext, 2023).

(Derindere Köseoğlu et al., 2023). Some of the energy companies in Russia have started to perform well during the invasion, but this increase in performance has not been nearly enough to bring the index back to its state before the invasion (Q.ai, 2022). Therefore, even though the Energy sector has performed well in Russia during times of increased geopolitical tension, as the effects in other sectors have been more severe, the index has ultimately decreased significantly due to the geopolitical tension. Thus, the fact that the Energy sector is the largest sector in the MOEX index, is not able to keep the returns of the index positive during geopolitical tension.

Figure 21 illustrates the sector allocation of the S&P 500 index. All of the three largest sectors Information Technology, Financials, and Healthcare are positively exposed to the GPR index according to Figure 15. This means that the index returns are expected to decrease as the GPR index increases, and thus for the majority of the time the strategy should work as expected. The largest two stocks in the largest sector are Microsoft and Apple, which are companies operating globally. Thus, their performance may not be as affected by geopolitical tensions specifically in the United States but instead, their performance is also affected by GPR index changes in other countries, as their revenue streams come from multiple countries. For example, Microsoft and Apple have banned sales in Russia after the Ukraine invasion (LePore, 2022), and therefore the geopolitical tension in Russia affected the sales of the United States based companies. On the other hand, during the Ukraine Invasion also the GPR index of the United States increased, and therefore the strategy was able to detect the decrease in the equity index. Thus for the United States, the equity index is often affected by geopolitical tensions in other countries, but as the United States often intervenes in these conflicts, the geopolitical tensions of other countries are also seen

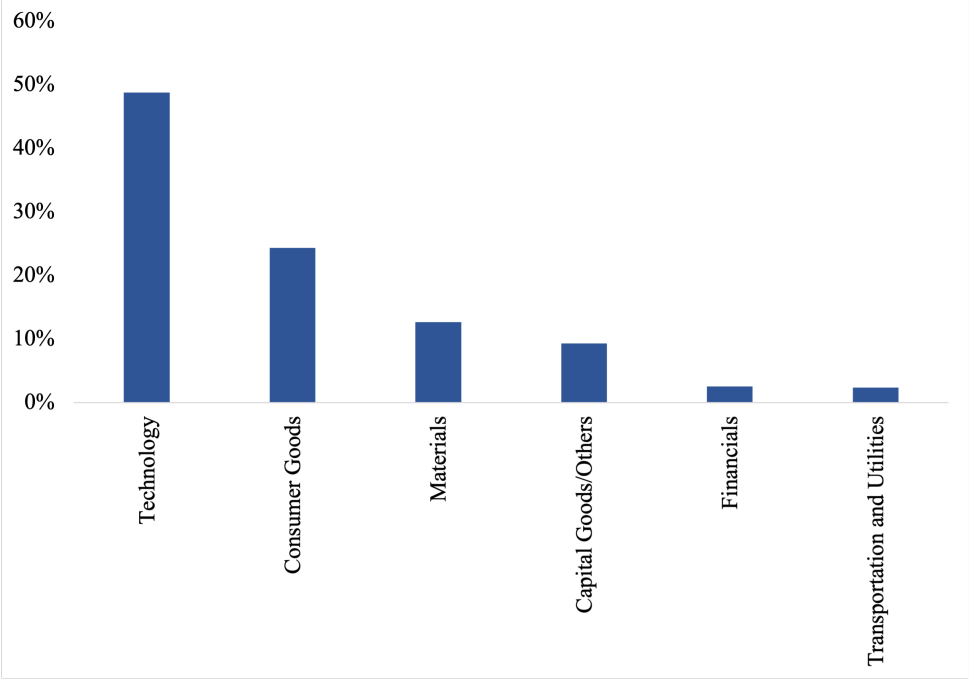

Figure 19: Nikkei225 sector allocation as of November, 2023 (Nikkei, 2023).

in the United States' GPR index, and thus the strategy works. The effects of different geopolitical events on specific stocks and indices are further investigated in Section 8.2.

An interesting observation in the S&P 500 index sector allocation is that as the largest sector is Information Technology, it seems that this sector is not as vulnerable to changing geopolitical tensions, as in Figure 6 it can be seen that even with large fluctuations in the GPR index the equity index continues to increase. Therefore in the case of the US, the strategy uses a larger cutoff value for the change in the GPR index, as the stock returns in the index are not changing significantly due to geopolitical tensions. On the contrary, in the MOEX index, the largest sector is Energy, which seems to be very vulnerable to geopolitical tensions according to Figure 5. Even though the maximum and minimum values of the change in the GPR index are similar in the US and Russia in Figure 8, the cutoff value used for the change in the GPR index in Russia is significantly smaller compared to the US. This might be due to the fact that the Energy sector has reacted more significantly to changes in the GPR index compared to the Information Technology sector during the studied period. Thus, the sector allocations are reflected in the cutoff values used in constructing the strategies.

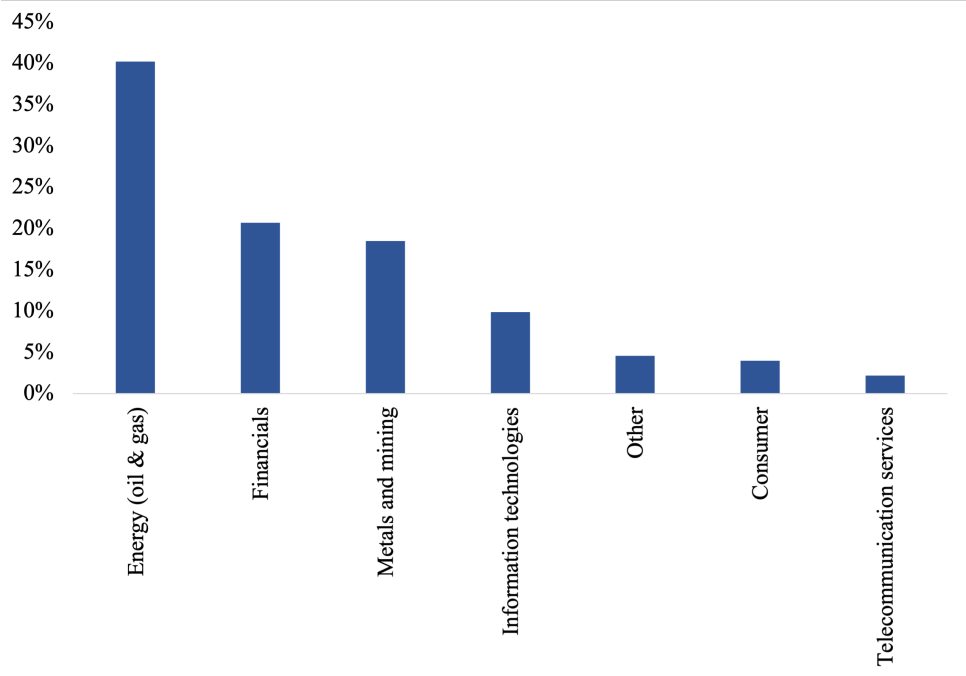

Figure 20: MOEX sector allocation as of March, 2021 (Exchange, 2021).

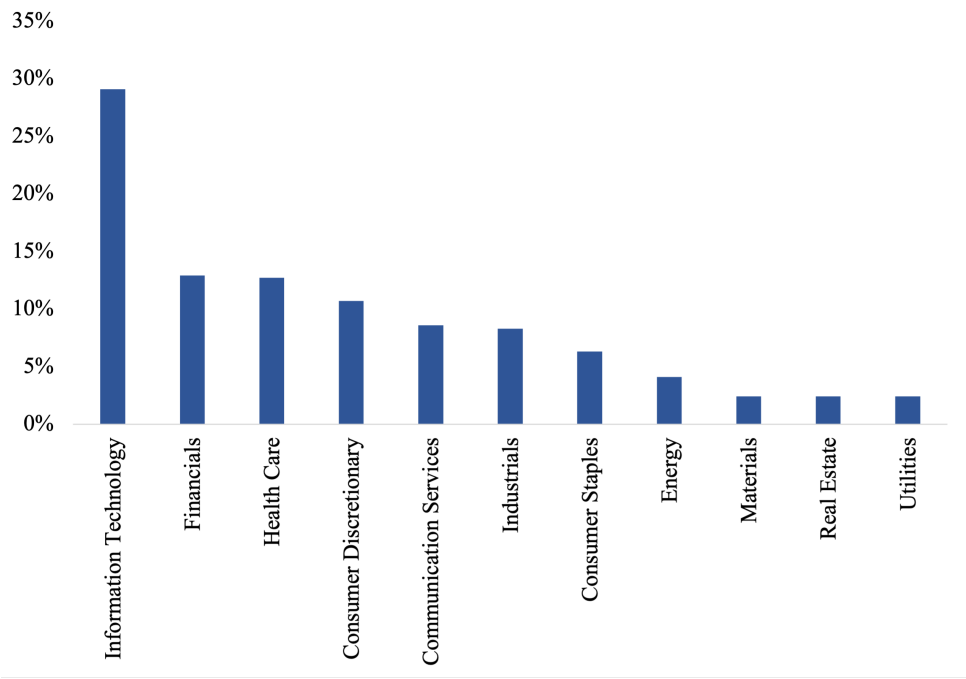

Figure 21: S&P 500 sector allocation as of November, 2023 (Indices, 2023).

8.2 Geopolitical events

8.2.1 Ukraine Invasion

One of the major geopolitical events in the last years has been the Russian invasion of Ukraine. The official date of the beginning of the invasion was the 24th of February 2022 (Q.ai, 2022). From the figures of development of the GPR indices in Section 4.2 it can be seen that the GPR index increases in each country during the beginning of 2022. Therefore the invasion of Ukraine has affected the geopolitical tensions of multiple countries. It can be also observed from the figures in Section 4.2 that the main equity indices of these six countries offered decreasing returns during and after the increase in the GPR index with different lags. This is most likely due to sanctions applied to Russia by multiple countries, which have affected the sales of companies from different countries.

In Section 8.1 it was already stated that the largest companies in the S&P 500 index banned sales in Russia after the invasion of Ukraine, which most likely affected the returns of the index. In addition, it was stated that most of the industries in Russia were negatively affected after the invasion, which resulted in a decrease in the MOEX index. A series of economic sanctions on Russia were announced by the US, EU, Japan, and multiple other countries (Saito, 2022), and these have affected the returns of multiple equity indices. According to Saito (2022), stock prices have fallen due to the cautious attitude of investors and the decline in growth prospects in the firms that have suspended or withdrawn business from Russia. In addition, in times of uncertainty investors often move their investments to safer quality assets, a phenomenon called the flight-to-quality (Papadamou et al., 2021), which further decreases the returns of the equity indices. Therefore, a decrease in the equity indices used in the strategies constructed in this thesis can be seen during and after the start of the Ukraine invasion.

Throughout the invasion, China has maintained a close relationship with Russia economically and geopolitically (Bo, 2023), and therefore China has been affected by the Ukraine invasion significantly. For example, the volatility in the exchange rate of the Russian ruble due to the invasion has adversely affected Chinese smartphone companies, which are responsible for 60% of the Russian smartphone market. According to Bo (2023), due to this close relationship, European countries have reconsidered their connections to China and the US government has seen China and Russia working as strategic partners. In addition, in March 2022, the US regulators named five Chinese companies listed on the New York Stock Exchange to be delisted unless they provide comprehensive audit documents to substantiate their financial statements, which provoked speculations of secondary sanctions to be implied to China (Bo, 2023). As China is the largest exporter to and second-largest importer of the EU, as well as the largest exporter and the third largest importer of the US (Bo, 2023), these secondary sanctions to China and the reassessment of the relationship in European countries, most likely affected the equity indices of China, the US, Germany, and France, which are used in this thesis.

Another factor decreasing the returns of the equity indices due to the Ukraine invasion is the fear of increasing energy prices, as Russia is one of the major energy

suppliers globally (Chen et al., 2023). According to Chen et al. (2023), the energy prices rose due to the multiple sanctions which resulted in increasing inflation and uncertainty, which on the other hand decreased the returns of multiple equity indices, such as the CAC40 and DAX indices. In general, an increase in oil prices often lowers the expected rate of economic growth and increases inflation expectations (Apostolakis et al., 2021), which explains the reaction of the global investors after the Ukraine invasion. Thus, the effect of increasing geopolitical tension in a specific country can also affect many other countries, depending on the role of the specific country in the global economy or a specific industry sector and the dependence of other countries in the country in question.

Another interesting point is that, as share prices typically reflect the expectations of numerous investors on future economic prospects (Leromain and Bierman, 2023), the equity index returns decreased since the Ukraine invasion was seen as unfair and "bad" in most countries, likely pointing to a decrease in future expectations. On the contrary, the stock markets reacted positively to the invasion of Iraq in 2003, as global investors saw as "good" news (Leromain and Bierman, 2023). Therefore, the effect of increasing geopolitical tensions on equity index returns is also dependent on how global investors perceive it, often from a Western perspective.

8.2.2 COVID-19 pandemic

Another significant event increasing the geopolitical risk index of all countries is the COVID-19 pandemic. The pandemic started in China at the end of 2019 and then spread quickly to the rest of the world, and was declared as a global pandemic in March 2020 (Ullah, 2023). The study made by Ullah (2023) confirms that the new COVID-19 cases and deaths significantly impact the market returns globally. This study also discusses the fact that the general fear and uncertainty due to the pandemic resulted in decreasing economic activity worldwide, particularly in the production and supply chains of goods and services. Thus, the pandemic generally affected all equity indices negatively, but the magnitude of this effect is dependent on the sector allocation of each equity index, as different industries were affected differently by the pandemic.

Mazur et al. (2021) studied the US stock market performance after the outburst of COVID-19. In this study, they found that natural gas, food, healthcare, and software stocks earned positive returns, while stocks in the petroleum, real estate, entertainment, and hospitality sectors fell significantly. Thus, equity indices with larger allocations for example in software and health care, are expected to rise during the GPR index increase at the time of the pandemic. The six equity indices studied in this thesis include stocks from both industries performing well and from industries performing poorly during the pandemic. The results in Section 6 indicate that well-performing industries are not enough to avoid the initial decrease in the equity indices at the outburst of the pandemic, which is caused by the significant decrease in the poorly-performing industries. On the other hand, sector allocation to these well-performing industries may have helped different equity indices to bounce back after the initial shock.

Interestingly, the COVID-19 pandemic's effect on the equity index returns is not as

significant in the SSE Composite index in Figure 9, compared to the other countries. According to the study made by Hui and Chan (2022), one of the main reasons for this is the fact that the East Asian economies already have experience in dealing with similar situations, due to the SARS outbreak in 2003. Due to this prior experience, quarantine measures were taken immediately, and the investors and the people in the East Asian countries were most likely used to similar situations, and therefore they weren't as scared or concerned about the implemented restrictions. Hence, the equity index did not plummet as much as in the Western countries, for example. On the contrary, the European economies lack experience in dealing with such situations. In addition, most Western citizens believed that their freedom was more important than controlling the spreading of the pandemic, and thus the restrictions faced more resistance (Hui and Chan, 2022). This phenomenon led to a more significant decrease in equity indices in Western economies. Thus, the effect of increasing GPR index is dependent on experience with similar situations and the actions made by the government - if similar situations are not as common and therefore induce fear, anger, and uncertainty, investors are more likely to react more to these events.

8.2.3 France terrorist attacks

From Figure 3 it can be seen that France has two large spikes in January 2015 and in November 2015 in the GPR index, which are not identified in other countries. These increases in the GPR index are due to terrorist attacks in France, namely the January 2015 Charlie Hebdo attack and November 2015 Paris attacks (Ilalan, 2017). In general, it is observed that terrorist attacks have an effect on financial markets, for example leading to increases in investors' risk aversion (Karolyi, 2006). According to Karolyi (2006), terrorist attacks lead to reduced confidence and increased risk aversion of both companies and consumers, which results in lower consumption and investment activity. Thus, terrorist attacks can significantly affect the returns of the equity indices. From Figure 3 it is interesting to note that the CAC40 index returns decreased only a little bit and then increased significantly after the January 2015 attack, while after the November 2015 attack, the index returns decreased for a longer time period. This may be due to the fact that the November Paris attack had more casualties, with 17 dead in the January attack and 130 dead in the Paris attack (Brouard et al., 2018). The Paris attack was the deadliest attack since the World War 2 in France (Brouard et al., 2018).

The study by El (2019) shows that the CAC40 index showed no significant abnormal returns (negative or positive) on the day of the terrorist attack. Also Volodin and Mikhalev (2017) mention that the CAC40 continued to grow after the January attacks. This article also points out that different industries are differently affected by terrorist attacks, and therefore the returns of an equity index are dependent on the stocks that it includes and how those are affected by terrorist attacks. For example, after the November attack, the CAC40 index decreased, as companies included in the index that operate in transportation, hospitality, and aviation decreased significantly. On the other hand, even though tourism to France decreased after the January attack, there was no significant effect on the equity index returns. Therefore, the significance and the scope of the attack as well as the effect on individual stocks in the index influence

how significant the effect is on the equity index overall. This is a good example of how the strategy can make false predictions, even though the GPR index is increased, as the markets do not always react to news as expected. This means that in these two similar circumstances, the market reacts very differently to them, which the strategy is not able to detect, and therefore false predictions on the equity index movement are made at the beginning of 2015, but after the November case, the strategy successfully shorts the index as it decreases.

9 Conclusions

Predicting investment returns and hedging against market turmoil remains a challenge to investors. Especially the effect of geopolitical risk on financial markets has gained interest among investors over the last years, during which there has been an increased frequency of negative geopolitical shocks. This thesis aimed to investigate the relationship between equity index returns and geopolitical risk and utilize it to construct investment strategies, which could predict the movements of equity indices based on past changes in geopolitical risk. Thus, this thesis combined two important and current topics: geopolitical risk and investment returns, and aimed to reveal information about the relationship between these two concepts and how it could be used to hedge against changes in the geopolitical landscape.

The main hypothesis used in constructing the investment strategies was that there is a negative correlation between geopolitical risk and investment returns, meaning that when the geopolitical risk increases the investment returns are expected to decrease. This assumption was verified through the literature review as well as in the data analysis section, which revealed that the developments of the country-specific equity indices, as well as the Geopolitical Risk Index, seemed to have a negative correlation with a lag. The assumed relationship was additionally verified by calculating the correlation between the change in geopolitical risk and equity index returns. The negative correlation between GPR and the returns was then used to construct investment strategies for six different country-specific equity indices individually. Each of the investment strategies used past changes in geopolitical tension in a specific country to make monthly investment decisions to the main equity index of the country in question. In these strategies the monthly change in the GPR index was used to determine whether the investor should buy the equity index or short it each month: if the GPR had increased, the strategy shorted the equity index, and if the GPR had decreased, remained the same or the change was not significant, the equity index was bought. For each strategy, an optimal cutoff value for the change in the GPR was calculated, which determined whether the change was significant enough to trigger the decision to sell the index.

Overall, the constructed strategies were successful, in the sense that all of them outperformed the equity indices according to the Sharpe ratio, and most of the time, the strategies predicted the future movements of the equity indices correctly. The sensitivity analysis indicated that the strategies constructed in this thesis are based on an algorithm that could be used in the future, but in order for the strategies to perform well, the parameter values used in the algorithm need to be updated constantly as new data becomes available. Further analysis of the results revealed that the relationship between the GPR and equity index returns is more complex than what was initially assumed. The relationship can be affected by multiple factors such as the sector allocation of the equity indices as well as the nature of different geopolitical events and how people perceive and react to them. These factors can change the relationship between the GPR and returns to deviate from the assumption of negative correlation or make the relationship even stronger. The constructed strategies did not consider these factors but rather relied solely on the assumption of negative correlation, and

this explains why the strategies made false predictions from time to time, which was seen in the results from the percentage of correct predictions out of all predictions made by each strategy.

Although the strategies performed well against the equity indices, the constructed strategies could be improved in future development. The predictions of the movements in the equity index could be improved by taking into account the different factors that can change the relationship between GPR and investment returns. This would make the strategies better at adequately hedging against market turmoil, as the strategies would then be able to predict the more complex nature of financial markets and investor sentiment compared to the current assumption of the thesis. These factors could be added to the strategies with different variables that would consider for example the sector allocation of the different equity indices and how these are affected by geopolitical risk. Adding additional variables to the strategies that would together with the change in GPR determine the investment decision, would most likely decrease the amount of false predictions made by the strategies. Additionally, the investment strategies could be improved in the future if daily or weekly data for the country-specific GPR index becomes available. The constructed strategies used monthly data for the change in the GPR index, which is updated with a month's delay, and thus the strategies might not be able to react to changes in the GPR index quickly enough to benefit from the strategies' predictive power. In addition, the GPR index might fluctuate significantly within the month, but this fluctuation cannot be utilized in the constructed strategies as the country-specific GPR index is available only as monthly data. Thus, the strategies could benefit from daily values on the country-specific GPR indices, since it could improve their accuracy and reactiveness.

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