

Louvain School of Management

How did Russia's invasion of Ukraine on the 24th February 2022, affect global stock markets in terms of levels, volatility, and markets in terms of abnormal returns, volatility and regional transmission around this date ?

Author: Bemelmans Guillaume
Supervisor: Lassance Nathan
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Use of Artificial Intelligence

DeepL and ChatGPT supported the preparation of this dissertation in several ways:

- They helped improve the clarity and overall quality of the writing by suggesting alternative expressions and correcting grammatical, spelling, and syntactical errors.
- They assisted in condensing information from reliable sources and organizing the ideas in a more coherent structure.
- They supported the translation and reformulation of certain ideas into academic English.
- They contributed to the development and correction of R code used for the empirical analysis and the creation of graphs.
- They also helped me challenge my own reasoning by encouraging me to question certain methodological choices, interpretations, and conclusions.

Every AI-generated suggestion was reviewed critically before being incorporated into the dissertation. Particular attention was paid to the accuracy, relevance, coherence, and reliability of the content. I remain fully responsible for the final analysis, arguments, interpretations, and conclusions presented in this work.

Executive Summary:

This dissertation examines how Russia's invasion of Ukraine on 24 February 2022 affected global financial markets. It analyses whether the shock influenced returns, volatility and regional transmission in the same way across countries and asset classes. The study uses Bloomberg data on equity indices, volatility indices and commodities.

The empirical analysis combines three methods. The event study measures abnormal returns around the invasion date. GARCH and EGARCH models examine changes in volatility and risk dynamics. Panel regressions test whether regional differences remain significant after controlling for market-specific characteristics and common daily shocks.

The results show a clear but uneven financial impact. Eastern Europe was the most affected equity region. Every market in the region recorded at least one significant CAR, and the median GARCH impact score reached 106.0%. Hungary was the most affected equity market, with a volatility impact score of 198.5%. Western Europe also reacted significantly, especially Italy, France and Germany, but with lower intensity. The United States was less directly affected. None of the S&P 500 CARs were significant at the 5% level, and its volatility impact score was only 19.1%.

Commodities followed a different pattern. Brent oil recorded a significant CAR(-5,+5) of 14.18%, while gold recorded a significant CAR(-10,+10) of 8.36%. These positive returns highlight the role of energy supply risk and safe-haven demand.

The panel analysis confirms these findings. On the event day, Eastern Europe underperformed the United States by 8.21 percentage points. Western Europe underperformed by 4.51 points and emerging markets by 5.13 points. Absolute returns also increased significantly, showing that the invasion affected both prices and market instability.

Overall, the invasion was not a uniform global market shock. Its effects were strongest in regions closest to the conflict, more moderate in Western Europe and more indirect in the United States. The main contribution of this dissertation is to show that geopolitical risk must be analyzed through returns, volatility, regional exposure and differences between asset classes.

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Intro:

Russia's invasion of Ukraine in February 2022 is one of the most significant geopolitical and economic shocks of the 21st century. The sudden escalation of the conflict disrupted global trade, triggered waves of financial sanctions, and caused widespread uncertainty in energy and commodity markets. Global stock markets reacted almost immediately with major indices fell sharply in the days following the invasion, before experiencing prolonged volatility and very different recovery trajectories across regions.

This topic has a significant interest to finance practitioners and researchers alike. It raises key questions relating to the management of geopolitical risk, international diversification and the resilience of markets to external crises for investors, portfolio managers and policymakers. The Russia-Ukraine conflict provides an especially relevant case study for analyzing the transmission of geopolitical shocks to financial markets in academic research. It allows us to assess whether the observed reactions are temporary or persistent, whether certain regions have been more affected than others and to what extent market correlations have strengthened during this period.

This dissertation will focus primarily on the impact of the 24th February 2022 and the period immediately surrounding that date on global stock markets. The aim will be to analyze the performance of the main indices before and after the invasion to measure changes in volatility, and to identify any contagion effects between markets in the days and months following the event. Particular attention will be paid to explanatory factors such as rising energy prices and the geopolitical uncertainty generated by the conflict.

So, the research question of this thesis is: ***“How did Russia’s invasion of Ukraine on the 24th February 2022, affect global stock markets in terms of levels, volatility, and markets in terms of abnormal returns, volatility and regional transmission around this date?”***

This question aims to capture three dimensions of market behaviour. First, it seeks to measure the direct effects of the invasion and the implicit related events (sanctions announcements, supply disruptions, diplomatic negotiations) on stock prices. Second, it examines changes in volatility and the persistence of risk over time. Third, it explores market interactions and the propagation of shocks to determine whether international diversification has been weakened by an increase in global correlations.

The empirical base of this study will combine three different methods: event studies, GARCH and EGARCH volatility models, and panel data regression.

First, event studies who was demonstrated by Mackinlay in 1997, which is used to measure the impact of specific event on financial markets based on price movements observed around the data of the event (MacKinlay, A. C, 1997). It's based on idea that any information is quickly reflected in shared prices if markets are efficient. In practice, the method involves comparing the returns observed after the event with normal returns estimated over a prior period to calculate abnormal returns. These can then be aggregated over several days using cumulative abnormal returns (CAR), by that measuring the total effect of the shock (Kothari & Warner, 2004). In this thesis, this approach will be used to analyze the reaction of the main stock markets around 24 February 2022 and during the days following the invasion of Ukraine.

Secondly, GARCH-type volatility models are used to analyze changes in market risk because they explicitly model the fact that volatility is not constant over time. In crisis periods, financial markets often display volatility clustering, meaning that large price movements tend to be followed by further large movements. Developed from the ARCH and GARCH literature, these models estimate conditional volatility from past shocks and past volatility. In this thesis, the empirical implementation focuses on univariate sGARCH, GJR-GARCH and EGARCH models estimated market by market, in order to compare how strongly the Russia-Ukraine invasion changed volatility across countries, regions, and asset classes (Zhang et al., 2023) and (Takahashi, M., Omori, Y., & Watanabe, T, 2023).

Finally, panel data regressions enable the simultaneous analysis of multiple financial markets across several time periods that combine both the time dimension and the cross-sectional dimension (Zulfikar, 2019). Unlike event studies or GARCH models, they provide a more comprehensive view of the differences between markets and how these evolve over time. They also allow for the control of characteristics specific to each country or index like the level of economic development or the institutional framework (Ahlawat, 2025). In this thesis, this method will be used to compare the impact of the invasion of Ukraine on various global stock markets like the method of Breuer (Breuer, 2024).

The data used in the empirical analysis are sourced from Bloomberg. The dataset consists mainly of daily closing prices for global stock-market indices, volatility indices and commodities. Equity indices are used as proxies for countries or regions, for example CAC for France, DAX for Germany, FTSEMIB for Italy, BUX for Hungary, WIG20 for Poland, SPX for the United States, SHCOMP for China, NIFTY for India and NKY for Japan. Using daily data and a broad, cross-market sample enables price reactions, volatility changes and regional heterogeneity to be compared around the invasion date.

This topic is of significant scientific interest as it enables the analysis of the impact of a major geopolitical shock on global financial markets within a clearly identifiable empirical framework. Russia's invasion of Ukraine constitutes an exogenous event that allows for the testing of several financial theories relating to market efficiency, international contagion, investor behaviour and safe-haven assets. It also offers an opportunity to study the transmission of geopolitical risk across regions and asset classes, as well as differences in resilience between developed and emerging markets. Finally, this research may contribute to a better understanding of financial reactions to future international crises.

Context:

The 24th February 2022, Russia launched a military invasion on a huge extent in Ukraine that beginning one of the most geopolitical and economic shocks of these recent years. This event quickly went beyond the regional framework to affect the global economy, international trade and financial markets. In the early hours of the invasion, investors reacted of the rising uncertainty with large sell-offs on stock markets, increased volatility, and a shift of capital toward assets that were considered safe havens, such as gold or the US dollar. The world's major financial markets have recorded sharp corrections and particularly in Europe which is a region directly exposed to the economic consequences of the conflict.

This crisis occurred in an economic context already weakened by the consequences of the COVID-19 pandemic. Since 2021, the global economy has faced an uneven recovery, persistent supply-chain disruptions, and a sharp rise in inflation. Central banks were gradually starting to raise interest rates in order to limit inflationary pressures, which was already reinforcing tensions in financial markets. The invasion of Ukraine has exacerbated these imbalances by driving up energy and commodity prices. As Russia is strategically important for global exports of gas, oil, and some others commodities, fears about Europe's energy supply have quickly gained investor concerns and the prospect of an economic slowdown.

Beyond the direct economic consequences, the war has also led to the imposition of exceptional financial and trade sanctions against Russia. The exclusion of some Russian banks from the SWIFT system, trade restrictions and the freezing of international assets have increased uncertainty in global markets. In a highly globalized and interconnected financial system, these tensions have contributed to increasing correlations between markets and reinforcing the phenomena of financial contagion between regions and asset classes. Therefore, the invasion of Ukraine provides a particularly relevant framework for analyzing

how a major geopolitical shock influences stock-market performance, market volatility, and risk-transmission mechanisms on an international scale.

Literature review:

1. Geopolitical risk as a source of macro-financial instability

Geopolitical risk has become an important topic in financial economics, further more since recent conflicts have shown that political tensions can quickly become economic and financial shocks. The Russian invasion of Ukraine is a clear example of this mechanism. It was not only a military event. It also created uncertainty about energy supply, inflation, sanctions, trade relations, monetary policy, and future economic activity. For this reason, the invasion can be analyzed as a geopolitical shock with effects on stock market levels, volatility and contagion.

A central reference for understanding this concept is Caldara and Iacoviello. Their contribution is important because they define geopolitical risk as the threat, realization and escalation of adverse events related to wars, terrorism, and tensions between states. This definition is directly relevant to the Russia-Ukraine war because the invasion represents both the realization of war and the escalation of international geopolitical tensions. Their paper also provides a way to measure geopolitical risk through the Geopolitical Risk Index which is based on newspaper coverage of geopolitical tensions. This is useful for financial research because it transforms geopolitical risk from a qualitative concept into a measurable variable (Caldara and Iacoviello, 2022).

The contribution of Caldara and Iacoviello is mainly theoretical and methodological. It helps to explain why geopolitical risk matters for financial markets. Their findings suggest that higher geopolitical risk is associated with lower investment, weaker employment, greater uncertainty and lower stock prices. This gives a strong basis for expecting that the invasion of Ukraine could affect equity markets. If investors expect lower growth, higher costs, inflationary pressure or weaker corporate profits, stock prices may fall. If uncertainty increases, market volatility may also rise.

However, their work should not be used as direct link of the stock market impact of the Russian invasion of Ukraine. The paper provides a general framework for geopolitical risk, but it does not directly test abnormal stock returns, volatility, or contagion about this problematic. The value for this thesis is to build the theoretical foundation. It explains why a

geopolitical shock can influence financial markets, while the empirical part of this thesis will test whether this effect actually appeared in global stock indices.

This distinction is important. The objective of this thesis is not only to say that geopolitical risk exists, but to study how one specific event affected markets. The invasion of Ukraine must therefore be analyzed as a particular geopolitical shock with these special consequences that are not the same for every geopolitical shocks, not only as a general increase in risk. This is where the other documents add value.

2. Not all geopolitical shocks are alike

A key limitation in some parts of the geopolitical risk literature is the tendency to treat geopolitical shocks as if they were homogeneous. In reality, different geopolitical events do not affect the economy in the same way. A terrorist attack, a trade dispute, a nuclear threat and a military invasion may all increase geopolitical risk, but their economic effects can be very different. This is particularly important for this thesis because the Russian invasion of Ukraine was not a simple increase in uncertainty. It was a realized war shock, with direct consequences for energy supply, commodity prices, inflation, and economic expectations.

Zhang and al. provide an important contribution to this point. Their paper, “Not all geopolitical shocks are alike”, studies the reaction of crude oil prices to different categories of geopolitical risk. Instead of using only a broad geopolitical risk index, they distinguish between several categories, such as military buildups, nuclear threats, war threats, terror threats, terror acts, the beginning of war and the escalation of war. This approach is useful because it shows that the type of geopolitical event matters (Zhang and al, 2023).

Their results show that most geopolitical shocks can affect crude oil prices, but the magnitude, direction, and persistence of the effect differ across categories. War-related shocks are especially important because they tend to create stronger and more persistent effects on oil markets. The paper also shows that geopolitical shocks can affect oil supply, aggregate demand and oil price uncertainty. This matters for the present thesis because oil and energy prices are one of the main channels through which the Russia-Ukraine war may have affected equity markets.

The relevance for stock markets is indirect but important. Higher oil prices can increase production costs, reduce profit margins, raise inflation expectations and put pressure on central banks to tighten monetary policy. These mechanisms can reduce stock valuations and increase market volatility. The effect may also vary across countries. Energy-importing

economies, especially in Europe, may be more exposed than energy-producing countries or economies less dependent on Russian energy.

Zhang et al. also mention that the 2022 Russia-Ukraine conflict caused strong increases in WTI and Brent crude oil prices over several months, contributing to severe energy pressure in Europe. This helps to justify why the European stock markets may have reacted more strongly than other markets. It also supports the idea that the thesis should not only analyze a global stock market index, but compare several regions and countries.

This article adds a more precise view of geopolitical shocks. Caldara and Iacoviello explain what geopolitical risk is and how it can be measured. Zhang et al. show that the effects depend on the type of geopolitical shock. For this thesis, the Russian invasion of Ukraine should be considered as a war-related shock, with specific transmission channels through energy prices, inflation, and uncertainty.

3. Commodity and energy markets as transmission channels

The Russia-Ukraine war had a strong effect on commodity markets. This is an essential point for the thesis because the reaction of stock markets cannot be understood without considering energy and commodity channels. The invasion affected expectations about gas supply, oil prices, food prices and trade flows. These changes were especially relevant for Europe, which was more exposed to Russian energy than many other regions.

Aizenman and al. provide evidence on this point. Their paper focuses on geopolitical shocks and commodity market dynamics during the Russia-Ukraine conflict. This makes it more directly related to the event studied in this thesis than many general papers on geopolitical risk. The authors analyze how geopolitical news related to the invasion affected agricultural and energy markets. Their results show that the conflict affected wheat, corn and especially European natural gas.

This paper is valuable because it identifies concrete transmission channels. The stock market reaction to the invasion was not only caused by fear or uncertainty. It was also linked to real economic mechanisms. Higher gas prices can increase costs for firms, reduce household purchasing power, raise inflation and weaken growth expectations. Higher food and energy prices can also create pressure on monetary authorities. Investors may then revise their expectations about company earnings, discount rates and risk premia (Aizenman and al, 2024).

The European natural gas result is particularly important. It supports the idea that the impact of the invasion was not the same across all regions. European economies were more exposed

to the energy consequences of the war, while the United States and some Asian markets were affected through more indirect channels. This helps justify a comparative analysis between European, American, Asian and emerging stock markets.

The contribution of Aizenman and al. is different from that of Zhang and al. Zhang and al. focus mainly on oil and on the categories of geopolitical shocks. Aizenman and al. focus more directly on the Russia-Ukraine conflict and its effect on several commodity markets. Taken together, the two sources strengthen the argument that energy and commodity prices are central channels between the invasion and financial markets.

However, these papers do not directly answer the main research question of this thesis. They focus on commodities, not on stock market abnormal returns, volatility, or contagion. Their role is therefore to explain the mechanism behind the expected stock market reaction. They help justify why the invasion may have affected equity prices and volatility, but they must be complemented by empirical studies on stock markets.

4. Heterogeneity of geopolitical shocks and macroeconomic effects

Another important contribution comes from Anttonen and Lehmus. Their paper studies the macroeconomic effects of two recent geopolitical events: the Russian invasion of Ukraine and the outbreak of the Israel-Hamas war. Their main argument is that geopolitical shocks are heterogeneous and should not be treated as identical events as there is a link with Zhang and al. This is useful for the thesis because it challenges the idea that an increase in geopolitical risk always has the same economic consequences.

The authors show that adverse geopolitical events can have either an inflationary or a deflationary effects, which it depends on the transmission channels. In their analysis, the Russian invasion of Ukraine had an inflationary effect on euro area consumer prices, while the outbreak of the Israel-Hamas war had a deflationary effect. Both events reduced euro area GDP but their effect on inflation differed. This result is important because it shows that the macroeconomic consequences of geopolitical shocks relies on the context (Anttonen and Lehmus, 2025).

For the Russia-Ukraine invasion, Anttonen and Lehmus find that the shock worked through supply disruptions, energy inflation and uncertainty. They estimate that without the Russian invasion, euro area inflation would have peaked around 8% instead of 10.6% in October 2022. They also estimate that almost 1% of euro area real GDP was lost in 2022 because of the invasion. These results are highly relevant for this thesis because they provide macroeconomic evidence that the invasion had a strong effect on the euro area.

This paper adds an important critical dimension. It suggests that using an average geopolitical risk shock may hide the real effect of a specific event. Two events can produce similar increases in a geopolitical risk index but have very different economic consequences. This means that the invasion of Ukraine should be studied as a specific shock, rather than as a simple rise in global geopolitical risk.

Another key point of this study is, if geopolitical shocks are heterogeneous, the analysis must be careful with the event window. Markets may have reacted before the 24th February 2022 because tensions were already increasing. They may also have continued to react after the invasion because sanctions, energy disruptions and monetary policy expectations evolved over time. A short event window can capture the immediate market reaction, but wider windows are useful to study persistence and adjustment.

The paper also supports the idea that Europe should be analyzed separately. The euro area was strongly affected by the energy and inflation channels. This means that European equity markets may show stronger abnormal returns, higher volatility or stronger contagion than less exposed markets. This creates a clear link between macroeconomic literature and the empirical stock market analysis.

5. Link with stock market levels, volatility, and contagion

The four documents together provide a coherent basis for the research question. Caldara and Iacoviello provide the general concept of geopolitical risk. Zhang and al. show that the type of geopolitical shock matters. Aizenman and al. show that the Russia-Ukraine conflict affected commodities and energy markets. Anttonen and Lehmus show that the invasion had important macroeconomic effects in the euro area and that geopolitical shocks should be analyzed in context.

These sources help explain why the invasion could affect stock market levels. Stock prices reflect expectations about future cash flows and discount rates. If the invasion were to increase uncertainty, inflation, energy costs and recession risks, investors might revise their corporate profit forecasts downwards. This is likely to result in negative abnormal returns around the time of the invasion, particularly in the markets most exposed to the conflict.

They also help to explain why volatility might increase. Geopolitical shocks create uncertainty about future policy, sanctions, energy supply and economic growth. When investors have difficulty pricing future outcomes, market movements become larger and less stable. This justifies the use of volatility models such as GARCH or EGARCH in the empirical part of the thesis.

Finally, the documents support the analysis of contagion. The invasion was not only a local shock. It affected commodity markets, inflation expectations, monetary policy and investor sentiment across several regions. This creates the possibility of stronger co-movements between stock markets. However, contagion must be defined carefully. A simple increase in correlation is not enough to prove contagion, because correlations often rise mechanically during periods of higher volatility. The thesis therefore needs to distinguish between normal interdependence and true contagion effects.

6. Research gap and contribution of the thesis

The existing literature provides strong reasons to expect that the Russian invasion of Ukraine affected financial markets. However, the literature also shows that the issue is more complex than a simple negative market reaction. Geopolitical risk can affect markets through various channels. The effects can vary depending on the type of shock, the region, the time window and the exposure of each market to energy, trade, and macroeconomic risks.

The main gap addressed by this thesis is that many studies focus on only one dimension of the shock. Some papers analyze geopolitical risk in general. Others focus on commodity prices, inflation or macroeconomic effects. Fewer studies combine stock market levels, volatility and contagion around the same event. This thesis contributes by analyzing the invasion of Ukraine as a specific geopolitical shock and by testing its impact on global stock markets through several complementary dimensions.

The thesis will therefore build on the existing literature but also challenge it. It will not assume that all geopolitical shocks have the same effect. It will not assume that all countries reacted in the same way. It will also not assume that a short-term fall in stock prices is the only relevant effect. Instead, the analysis will examine whether the invasion affected abnormal returns, whether it increased volatility and whether it strengthened cross-market linkages.

This approach is useful because the invasion of Ukraine was a complex shock. It was a war shock, an energy shock, an inflation shock and an uncertainty shock at the same time. These different dimensions may have had varying impacts on markets. European markets may have reacted more strongly due to their energy exposure. Emerging markets may have been affected by risk aversion and capital flows. The United States may have been less directly exposed but still affected through inflation and monetary policy expectations.

Overall, the literature suggests that the Russian invasion of Ukraine provides a relevant case for studying how geopolitical events affect financial markets. The four documents used in this

section add value because they explain the shock from different but complementary angles. Together, they justify the empirical strategy of this thesis: an event study to analyze stock market levels, volatility models to study risk dynamics, and contagion or connectedness analysis to examine cross-market transmission.

Scientific literature :

1. Event study

Event study is a quantitative analysis method demonstrated by MacKinlay in 1997, where he defines it as “measuring the impact of a specific event on firm value using financial market data.” That means if markets are efficient, new information is incorporated immediately into asset prices. So instead of measuring economic impact years later, we can measure it in days or even minutes using stock returns. (MacKinlay, A. C, 1997). This definition remains on the market, but with the econometric structure of Kothari & Warner in 2004, which can be applied to more general events, such as wars because this methodology examines stock price behaviour around corporate or economic event and interpret abnormal performance as a measure of wealth effects. (Kothari, S. P., & Warner, J. B, 2004). More recently, Miller in 2023 describes event studies as tools to estimate the impacts of dynamic interventions, allowing analyst to observe how outcomes evolve before and after an event. (Miller, D. L, 2023).

The implementation of an event study follows a structured sequence of econometric steps designed to isolate the market reaction of a clearly defined event. The first step is to define the event and the time intervals over which returns will be analyzed. The standard and first procedure of MacKinlay, the analyst specifies an event date which is denoted as $t = 0$, an event window that surround this date like $[-20, +20]$, and an estimation window that is period of time before the event window like for example $[-300, -30]$ that is used to estimate the parameters of the expected return model. The practical reason for separating the estimation from the event window is to prevent that the event itself influences the estimation of the “normal” performance”, which can be a bias abnormal return measurement. (MacKinlay, A. C, 1997).

The second step is to specify and estimate the normal (expected) return model, which defines what returns would have been in the absence of the event. The most common model is the market model that is the expression of the asset’s return by a stable linear function of the market return:

$$R_{it} = \alpha_i + \beta_i R_{mt} + e_{it}$$

Where R_{it} is the observed return of asset i at time t , R_{mt} is the market return, and e_{it} is an idiosyncratic disturbance. The coefficients α_i and β_i are estimated using observations from the estimation window. (MacKinlay, A. C, 1997).

The third step is the explicit computation of abnormal returns, which are the key objects of interest in the event study model. MacKinlay defines the abnormal return as the difference between the realized return and the expected return of the normal performance model:

$$AR_{it} = R_{it} - E(R_{it}|X_t)$$

Where $E(R_{it}|X_t)$ is the expected return of the information used in the normal return model. In this case, abnormal returns represent the component of performance that cannot be explained by typical market movement and are interpreted as the market's response to new information about the event. (MacKinlay, A. C, 1997). Kothari & Warner further emphasizes that abnormal returns can be viewed as an estimate of the unexpected change in security holder wealth linked to the event. (Kothari, S. P., & Warner, J. B, 2004).

The fourth step is time aggregation, events may influence prices not only at time $t = 0$ (date event) but also around days due to information leakage, delays reactions or microstructure effects. In the MacKinlay approach, analyst first compute an average abnormal return across units and then aggregate abnormal returns over time. (MacKinlay, A. C, 1997). But Kothari & Warner presents cumulative abnormal returns (CAR) as the most common time aggregation methods that is defined as:

$$CAR(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_t$$

This quantity measures total abnormal performance during the event window $[t_1, t_2]$. In economic terms, the CAR represents the total unexpected gain or loss during the given time period. It can be calculated by subtracting the expected returns from the abnormal return on a trading strategy that holds the asset throughout the event window. (Kothari, S. P., & Warner, J. B, 2004). The choice of $[t_1, t_2]$ is also a strategic decision because narrow windows reduce contamination by unrelated events, while broader windows capture potentially slower adjustment.

The fifth step is to conduct statistical inference to determine whether abnormal performance is significantly different from zero. The standard null hypothesis is that the event has no effect, meaning that average abnormal returns (and by extension CAR) are zero. Miller describes the construction of a test statistic in which the CAR is divided by its estimated standard deviation:

$$t = \frac{CAR}{SE(CAR)}$$

Inference depends crucially on correct estimation of $SE(CAR)$. (Miller, D. L, 2023).

Kothari & Warner highlights that event studies can face complications such as cross-sectional dependence (assets moving together) and event-induced increases in volatility, both of which can lead to understated standard errors and overstated significance if not properly handled. This point is particularly relevant for geopolitical shocks such as the Russia–Ukraine war, because such events are plausibly associated with sudden increases in uncertainty and market-wide volatility (Kothari, S. P., & Warner, J. B, 2004).

The sixth step is to interpret the results using a dynamic perspective and, when appropriate, an event-time regression framework. Miller formalizes event studies as models that estimate dynamic treatment effects across event time by regressing outcomes on a set of event-time indicators while controlling for unit and time fixed effects:

$$y_{it} = \sum_j \gamma_j D_{i,t-j} + \alpha_i + \delta_t + e_{it}$$

In this framework, each coefficient γ_j captures the average deviation in the outcome y_{it} at event time j relative to a baseline period. The pre-event coefficients ($j < 0$) provide an empirical check for anticipation or pre-trends, while the post-event coefficients ($j \geq 0$) describe the persistence and evolution of the event’s impact. Miller interpreted in the context of the Russia–Ukraine war, statistically significant negative abnormal returns or CARs for broad indices would indicate a negative wealth effect of the invasion, while heterogeneous responses across regions or sectors (for example, energy versus technology) would reveal differential exposure and redistribution effects. (Miller, D. L, 2023).

2. Volatility model GARCH and EGARCH:

Although the event-study methodology is useful to identify abnormal returns around a precise date, it is less suited to capture the evolution of market risk over time. This distinction is important in the case of the Russia-Ukraine war because the invasion was not only a price shock; it also generated uncertainty about energy supply, inflation, sanctions, and future economic activity. Empirical research on geopolitical risk and stock-market volatility shows that geopolitical shocks can affect markets not only through returns, but also through uncertainty and volatility dynamics (Zhang et al., 2023). For this reason, the analysis is complemented by GARCH-type volatility models, which are specifically designed to model time-varying conditional variance.

In financial econometrics, volatility is generally interpreted as the conditional variance of returns. A key empirical feature of financial returns is volatility clustering: large shocks tend to be followed by large shocks, while calm periods tend to be followed by calm periods. This feature cannot be captured by a model assuming constant variance. The volatility literature also shows that financial volatility is persistent, partly latent, and difficult to observe directly, which explains the relevance of models specifically designed for conditional volatility (Takahashi, Omori, & Watanabe, 2023). The GARCH framework, which was developed from the ARCH model of Engle (1982) and the GARCH model of Bollerslev (1986), addresses this issue by allowing current volatility to depend on both past shocks and past volatility.

The common return equation used in this framework can be written as:

$$r_t = \mu + \varepsilon_t, \quad \varepsilon_t = \sigma_t z_t$$

where r_t is the return at time t , μ is the conditional mean, ε_t is the innovation, σ_t is the conditional standard deviation, and z_t is a standardized innovation with zero mean and unit variance. The central objective of the model is therefore to estimate σ_t^2 , the conditional variance of returns.

The standard GARCH(1,1) model expresses conditional variance as:

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

where ω represents the long-run volatility component, α captures the immediate reaction to new shocks, and β captures volatility persistence. A high value of $\alpha + \beta$ indicates that volatility shocks persist over time. This structure is relevant for the thesis because a geopolitical shock such as the invasion of Ukraine may generate a temporary or persistent increase in conditional volatility. Zhou et al. (2020) also underline that GARCH-type models are particularly useful to capture persistence and cross-sectional volatility dependence in financial markets, even if this thesis applies the models market by market rather than through a full network specification.

However, financial markets may react differently to negative and positive shocks. For example, bad news often increases volatility more strongly than good news of the same magnitude. This asymmetry is particularly relevant in a war context, where negative information about sanctions, energy supply or military escalation may trigger stronger uncertainty. The empirical analysis therefore also considers asymmetric GARCH specifications.

The GJR-GARCH model introduces an additional term for negative shocks:

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \gamma I(\varepsilon_{t-1} < 0) \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

where $I(\varepsilon_{t-1} < 0)$ is an indicator equal to one when the previous shock is negative. The γ coefficient measures whether negative shocks have an additional effect on volatility. This model is consistent with the asymmetric volatility approach introduced by Glosten, Jagannathan and Runkle (1993). The EGARCH model, introduced by Nelson (1991), models the logarithm of conditional variance:

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha(|z_{t-1}| - E|z_{t-1}|) + \gamma z_{t-1}$$

This specification is useful because it allows asymmetric effects and does not require the same positivity restrictions as the standard GARCH model. In the empirical analysis, this aspect is of particular importance, as several markets display asymmetric volatility responses during the crisis period. The choice of EGARCH model for many indices in the empirical results is therefore consistent with the literature on asymmetric financial volatility.

The choice of distribution law for innovations is also important. Financial returns often follow a non-normal distribution, with fat tails and sometimes skewness. The use of Gaussian errors may understate extreme movements during periods of crisis. For this reason, the empirical analysis compares Student-t, skewed Student-t and GED distributions. This is consistent with the volatility literature, which emphasizes that heavy-tailed distributions provide a more realistic representation of financial returns during periods of stress (Takahashi et al., 2023).

The broader literature also discusses multivariate GARCH, structural MGARCH and network GARCH models to analyze volatility spillovers across markets. Hafner, Herwartz and Maxand (2022) show how structural MGARCH models can help identify volatility transmission mechanisms, while Zhou et al. (2020) develop a network GARCH approach to model interactions between connected financial assets. These extensions are useful for full contagion modelling, but they are not the empirical focus of this thesis. This thesis uses univariate GARCH-type models estimated separately for each index and asset. The objective is therefore not to identify a complete structural transmission network, but to compare the intensity and persistence of volatility shocks across countries, regions, and asset classes. The panel model then complements this by testing regional heterogeneity in a cross-market framework.

Table 1: Model of garch and role

Model	Main purpose	Role in the thesis
sGARCH	Captures volatility clustering and persistence	Baseline volatility model for each market
GJR-GARCH	Allows stronger volatility reaction after negative shocks	Tests asymmetric responses to bad news
EGARCH	Models log variance and asymmetric effects	Useful when crisis volatility is asymmetric
Student-t / skewed Student-t / GED	Accounts for fat tails and non-normal returns	Improves crisis-period modelling

3. Panel data regression model:

Building on previous approaches, panel data regression is a natural step forwards in empirical analysis. While event studies measure short-term reactions around a specific event and GARCH models capture volatility and risk dynamics, panel models offer a more comprehensive perspective by enabling the simultaneous analysis of multiple markets over a long period.

Panel data regression is an econometric technique that combines cross-sectional and time-series data within a single dataset. In this context, several entities such as firms, countries or financial markets, are observed repeatedly over several periods. This structure enables researchers to analyze how variables change over time as well as the differences between entities. Panel data can therefore be defined as a dataset comprising the same cross-sectional units measured over several periods. (Zulfikar, 2019).

More specifically, the panel data relate to N individuals tracked over T periods. This type of data allows econometric relationships to be estimated whilst taking into account both the time dimension and the heterogeneity between the entities (Zulfikar, 2019). Compared with purely cross-sectional approaches or time series analyses, regression analysis using panel data offers a richer structure, which enhances the robustness of the empirical analysis and increases the number of observations available for estimation.

A standard panel regression model can be expressed as follows:

$$Y_{it} = \alpha + \beta X_{it} + u_{it}$$

where Y_{it} represents the dependant variable for entity i at time t , X_{it} represents the explanatory variables, and u_{it} is the error term. Panel regression models are generally estimated using methods derived from ordinary least squares (OLS), which aim to produce estimators

satisfying the properties of the best linear unbiased estimators (BLUE) under standard assumptions (Zulfikar, 2019).

One of the main advantages of panel data regression lies in its ability to account for unobserved heterogeneity. In financial and economic studies, different markets may exhibit structural characteristics that are difficult to measure directly, such as regulatory frameworks, levels of economic development and institutional frameworks. Panel data models account for these unobserved characteristics by incorporating individual and time-specific effects. (Ahlawat, 2025).

The two most commonly used specifications are the fixed-effects model and the random-effects model. The fixed-effects model assumes that individual characteristics that do not change over time can influence the dependent variable. The model captures these time-invariant factors by assigning a separate intercept to each entity. This approach enables researchers to isolate the effect of explanatory variables by focusing on the variations observed within each entity over time. (Breuer, 2024).

By contrast, the random effects model assumes that the effects specific to each entity are random and uncorrelated with the explanatory variables. Under this assumption, the model includes the entity-specific effects in the error term. This can produce more efficient estimates when the required conditions are satisfied. (Zulfikar, 2019). The choice between fixed effects and random effects are often determined by statistical tests such as the Hausman test, which checks for correlation between individual effects and the explanatory variables. (Breuer, 2024).

Another advantage of panel data is the larger number of observations available for the analysis. It combines information across entities and over time. This can improve the precision of the estimates and reduce problems linked to omitted variables or multicollinearity. (Ahlawat, 2025).

In financial research, panel regression models are widely used to analyze the impact of macroeconomic shocks, geopolitical risks and policy changes across multiple markets simultaneously. The panel structure enables researchers to compare the reactions of different markets to the same event whilst taking into account the specific characteristics of each country or market. (Ahlawat, 2025).

In this thesis, panel data regression serves as a key methodological tool for analyzing the impact of Russia's invasion of Ukraine on global financial markets. Whilst the event study methodology developed by MacKinlay highlights abnormal returns around the date of the

invasion and the GARCH model captures the dynamics of volatility, panel data regression allows for a broader analysis covering multiple markets and extending over time.

The use of panel data enables this research to compare the reactions of different financial markets whilst controlling for country-specific characteristics that may influence market behaviour. This approach enables the study to evaluate the impact of the geopolitical shock generated by the invasion on global markets and quantify these effects in terms of regions or financial indices.

The panel data analysis complements the event study and the volatility models. Together, these methods provide a broader understanding of how geopolitical conflicts affect global financial markets.

DATA:

The empirical database is built from daily closing prices extracted from Bloomberg. The indices are used as country or regional market proxies rather than individual firms: for example CAC for France, DAX for Germany, FTSEMIB for Italy, BUX for Hungary, WIG20 for Poland, SPX for the United States, SHCOMP for China, NIFTY for India and NKY for Japan. The sample also includes broader regional indices such as STOXX Europe 600 and MSCI Emerging Markets, volatility indices such as VIX and VSTOXX, and commodities such as Brent oil, WTI oil and gold.

Two complementary datasets were created based with the same data but not the same period. First, the event-study file contains markets and assets observed daily around the invasion, from January 2021 to December 2022 and with 24 February 2022 defined as $t = 0$, for an estimation window of $[-250; -21]$ and use five CAR windows: $(-1,+1)$, $(-5,+5)$, $(-10,+10)$, $(-20,+20)$ and $(-10,+50)$. The GARCH and panel files rely on a dataset covering series from 2 January 2015 to 31 December 2025; the panel regressions focus on 20 equity indices, while VIX, VSTOXX, Brent, WTI and gold are used as volatility and commodity transmission variables. Using this large dataset makes the comparison across countries, regions, and asset classes more complete, while the use of returns rather than price levels makes indices with different currencies and base values comparable.

Methods:

1. Event study:

In the empirical part of this thesis, the event study is operationalized around the 24 February 2022, which is treated as event day $t = 0$. The Excel model uses daily price observations and

computes daily returns for each index or asset. The estimation window is set from $t = -250$ to $t = -21$. It means that the normal return is estimated before the event period and is not contaminated by the invasion itself. This choice is consistent with MacKinlay's logic of separating the estimation period from the event window, and it adapts the framework to a global multi-asset comparison.

The empirical implementation follows a mean-adjusted return approach: the normal return is approximated by the average return observed during the estimation window. The abnormal return is therefore calculated as the realized daily return minus this estimated normal return ($AR_t = R_t - \bar{R}$) where $R_t = \frac{(P_t - P_{t-1})}{P_{t-1}}$ and $E(R_t) = \bar{R}$. These abnormal returns are then aggregated into cumulative abnormal returns (CAR) ($CAR = \sum AR_t$) over five events windows: CAR(-1,+1), CAR(-5,+5), CAR(-10,+10), CAR(-20,+20), and CAR(-10,+50). This design makes it possible to distinguish the immediate market reaction from the broader adjustment process that followed the invasion.

The interpretation is based on both the sign and the statistical significance of the CAR. A negative CAR indicates underperformance relative to the estimated normal return, while a positive CAR indicates outperformance. However, this dissertation only treats a result as statistically robust when its p-value is below 0.05. Results with p-values between 0.05 and 0.10 are discussed as suggestive or borderline evidence, but they are not interpreted as statistically significant at the 5% level. This distinction is particularly important because large geopolitical shocks can increase volatility and therefore make some economically large CAR statistically uncertain.

2. GARCH/EGARCH:

The GARCH/EGARCH empirical analysis is estimated on daily log returns for each index and asset separately. Returns are calculated as $r_t = \ln(P_t / P_{t-1})$, where P_t is the Bloomberg closing price at time t . This transformation makes markets with different currencies, index levels and base values comparable because the analysis is based on percentage changes rather than price levels.

Two samples are used. The full 2015-2025 window provides a long historical benchmark for volatility behaviour, while the focused 2021-2022 window isolates the period immediately before and after the invasion. For each market, three volatility specifications are compared: sGARCH(1,1), GJR-GARCH(1,1) and EGARCH(1,1). For each specification, Student-t,

skewed Student-t and GED innovation distributions are tested in order to account for fat tails and non-normal return distributions during crisis periods.

The retained model must satisfy three conditions: the estimation must converge, the volatility process must satisfy the required stationary conditions, and residual diagnostics must not indicate a clearly mis specified model. Among the potential models, the Bayesian Information Criterion (BIC) is used to select the preferred specification. This selection rule keeps the method systematic and avoids choosing models only because they produce stronger crisis effects.

The empirical volatility shock is then summarized through three indicators: the change in conditional volatility, the change in realized volatility and the change in mean absolute returns between the pre-war and acute-war periods. The impact score is computed as:

$$\text{Impact score}_i = \text{mean}(\Delta CV_i, \Delta RV_i, \Delta MAR_i)$$

In this formula, CV is conditional volatility, RV is realized volatility and MAR is mean absolute return. A high impact score therefore indicates a stronger increase in market risk, but not necessarily a negative return. This distinction is essential for commodities: Brent and WTI can show very high volatility scores while also recording positive returns, because the invasion increased energy supply risk.

Finally, the GARCH section also reports significant variance-effect counts for several crises windows: the event day, the invasion week, the acute one-month period and the broader 2022 war period. These tests are used as robustness evidence to determine whether the increase in volatility is statistically visible beyond a simple descriptive comparison of pre-war and post-war periods.

3. Panel-data empirical implementation:

The panel model uses daily log returns and absolute daily log returns for the equity indices as dependent variables. The explanatory variables capture the event day, the following one-month period and the rest of the 2022 adjustment phase. Market fixed effects account for the specific characteristics of each index. Two-way fixed effects also control for daily shocks that affected all markets. In this specification, the regional interaction terms show whether Western Europe, Eastern Europe or emerging markets behaved differently from the United States and from the common market movement.

Empirical hypotheses:

Before interpreting the empirical results, the analysis is structured around four hypotheses. These hypotheses are formulated as theoretical expectations based on the literature and on the economic transmission channels of the Russia-Ukraine war. They do not yet state the empirical outcome; they provide a framework that will be assessed in the empirical analysis.

Table 2 : Hypothesis of the thesis

Hypothesis	Expected effect	Economic rationale	Empirical test
H1: European equity markets reacted more strongly than the United States.	European equity indices are expected to show more negative abnormal returns than the US market around the invasion.	European economies were more directly exposed to the conflict through energy dependence, sanctions, inflation expectations and geographic uncertainty.	Comparison of CAR significance and magnitude across European indices and the S&P 500.
H2: Eastern Europe was the most exposed equity region.	Eastern European indices are expected to display stronger and more persistent negative abnormal returns than Western European indices.	Markets closer to the conflict may be more sensitive to geopolitical risk, regional security concerns and changes in risk premia.	Comparison of CAR windows and volatility impact scores between Eastern and Western Europe.
H3: Commodities reacted differently compared to equities.	Oil and gold are expected to show positive abnormal returns or stronger volatility responses and equity markets decline.	Oil prices may increase when investors expect supply disruptions. Gold may also rise as investors seek safer assets during periods of uncertainty.	Comparison of commodity CAR and volatility impact with equity-market reactions.
H4: The shock affected volatility beyond price levels.	The invasion is expected to increase conditional volatility, realized volatility, and absolute returns in the most exposed markets.	Geopolitical shocks increase uncertainty and make future cash flows, inflation, and policy responses harder to price.	GARCH/EGARCH comparison of pre-war and acute-war volatility indicators.

Empirical analysis:

1. Event study:

The analysis event study contains 25 markets and assets grouped into five categories: Western Europe, Eastern Europe, emerging markets, the United States, and commodities. The results confirm that the invasion of Ukraine did not generate a uniform market reaction. The strongest evidence is concentrated in European equity markets with a stronger effect in Eastern Europe, while the US market shows only borderline evidence and commodities move in the opposite direction.

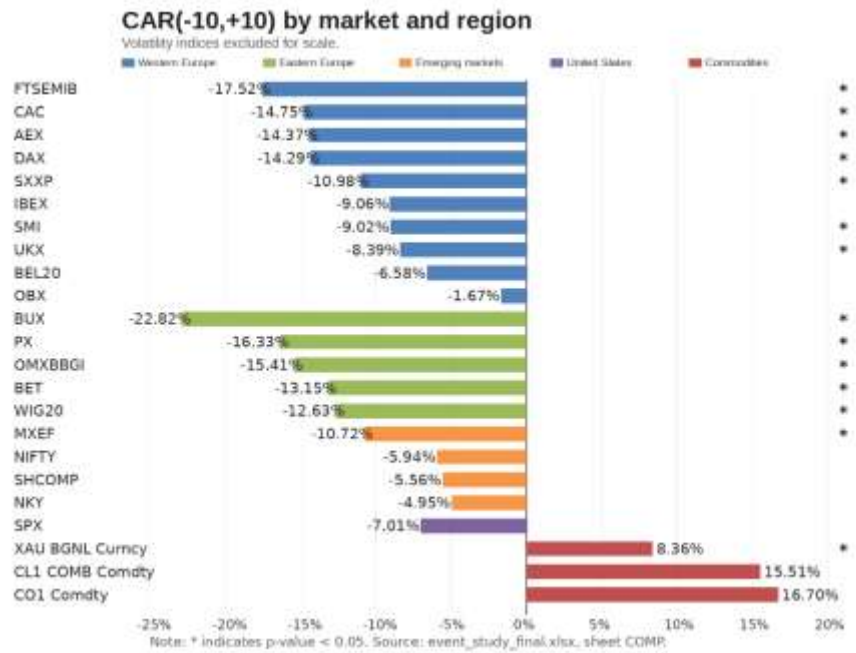
The very short CAR(-1,+1) window provides limited evidence for Western Europe and the United States, but it is already significant for some Eastern European markets. The Hungarian BUX records a CAR(-1,+1) of -4.67% with a p-value of 0.009, and the Polish WIG20 records -5.60% with a p-value of 0.004. This indicates that markets closer to the conflict reacted more immediately than broader global indices.

Table 3. Distribution of event-study significance by region

Region	Markets	Markets significant at 5%	significant observation	Bordeline observations	Strongest significant result
Western Europe	11	9	21	5	FTSEMIB, CAR(-10,+50) : -20.12% (p=0.012)
Eastern Europe	5	5	18	1	WIG20, CAR(-10,+50): -28.45% (p=0.001)
Emerging markets	4	2	2	5	MXEF, CAR(-10,+10): -10.72% (p=0.007)
US	2	0	0	2	\
Commodity	3	2	2	3	CO1 Comdty, CAR(-5,+5): 14.18% (p=0.035)

The medium event windows provide the clearest evidence. In Western Europe, the STOXX Europe 600, CAC, DAX, FTSEMIB, AEX, SMI and UKX show negative and statistically significant CAR on either CAR(-5,+5) or CAR(-10,+10). The largest Western European equity market losses are observed for Italy, France, and Germany: FTSEMIB reaches -17.52% on CAR(-10,+10), CAC reaches -14.75%, and DAX reaches -14.29%. These results support the interpretation that the invasion was gradually priced through sanctions, energy-market disruption and a broader repricing of European risk. (Annexe A1)

Figure 1. CAR(-10,+10) across markets by region, excluding volatility indices (Annexe A2)



Eastern Europe appears to be the region most affected by the invasion. Each of the Eastern European market included in the sample records at least one statistically significant CAR. Hungary shows the strongest reaction. Its CAR is significantly negative across all five event windows. The decline reaches -22.82% for CAR(-10,+10) and -27.96% for CAR(-10,+50). Poland and the Czech Republic also experience substantial negative reactions. Romania and the Baltic index remain significant over the medium term. These results may be explained by the region's geographic proximity to the conflict. Eastern European markets were also more exposed to geopolitical uncertainty and to concerns about energy supply and regional security. The results for emerging markets and Asian markets are less uniform. The MXEF index records a significant CAR of -10.72% over the CAR(-10,+10) window. NIFTY is also significant over the CAR(-5,+5) window with a CAR of -6.97%. China and Japan do not reach the 5% significance threshold. The invasion therefore affected some markets outside Europe. However, this effect was less consistent than the reaction observed across European markets.

The US market also records negative abnormal returns, but the statistical evidence is weaker. The S&P 500 has a negative CAR over the CAR(-5,+5), CAR(-10,+10) and CAR(-10,+50)

windows. None of these results are significant at the 5% level. The CAR(-10,+10) result is close to significance with a p-value of 0.064. The CAR(-10,+50) result is also close to significance with a p-value of 0.058. These findings may indicate that the US market adjusted more gradually to the shock. However, the evidence is not strong enough to conclude that the invasion caused a statistically significant abnormal loss in the US equity market. The volatility indices are not shown in Figure 1 because their CAR scale is different from equity and commodity markets; they are therefore better interpreted separately in the volatility-model section.

The commodity results confirm that the event study captures more than equity market losses. Brent oil records a positive and significant CAR(-5,+5) of 14.18%, reflecting energy supply risk after the invasion. Gold records a positive and significant CAR(-10,+10) of 8.36%, consistent with a safe-haven response. WTI oil and Brent oil also show borderline positive results on other windows. The invasion therefore produced a dual market reaction: negative abnormal returns for exposed equity markets and positive abnormal returns for energy and defensive assets.

Several results fall between the 5% and 10% thresholds and should be interpreted as suggestive rather than conclusive. These include SPX on CAR(-10,+10) and CAR(-10,+50), MXEF on CAR(-1,+1), CAR(-5,+5) and CAR(-10,+50), China on CAR(-10,+50), and Brent oil on CAR(-10,+10) and CAR(-20,+20). These borderline results are useful because they indicate where market pressure may exist, but they should not be presented as statistically significant findings at the 5% level.

Interpretation of the event-study results

Table 4. Regional interpretation of event-study significance and median CAR.

Region	Markets	Significant at 5%	Borderline 5-10%	Median CAR
Western Europe	11	21	5	-6.01%
Eastern Europe	5	18	1	-11.06%
Commodities	3	2	3	14.18%
Emerging markets	4	2	5	-4.62%
United States	2	0	2	-0.69%

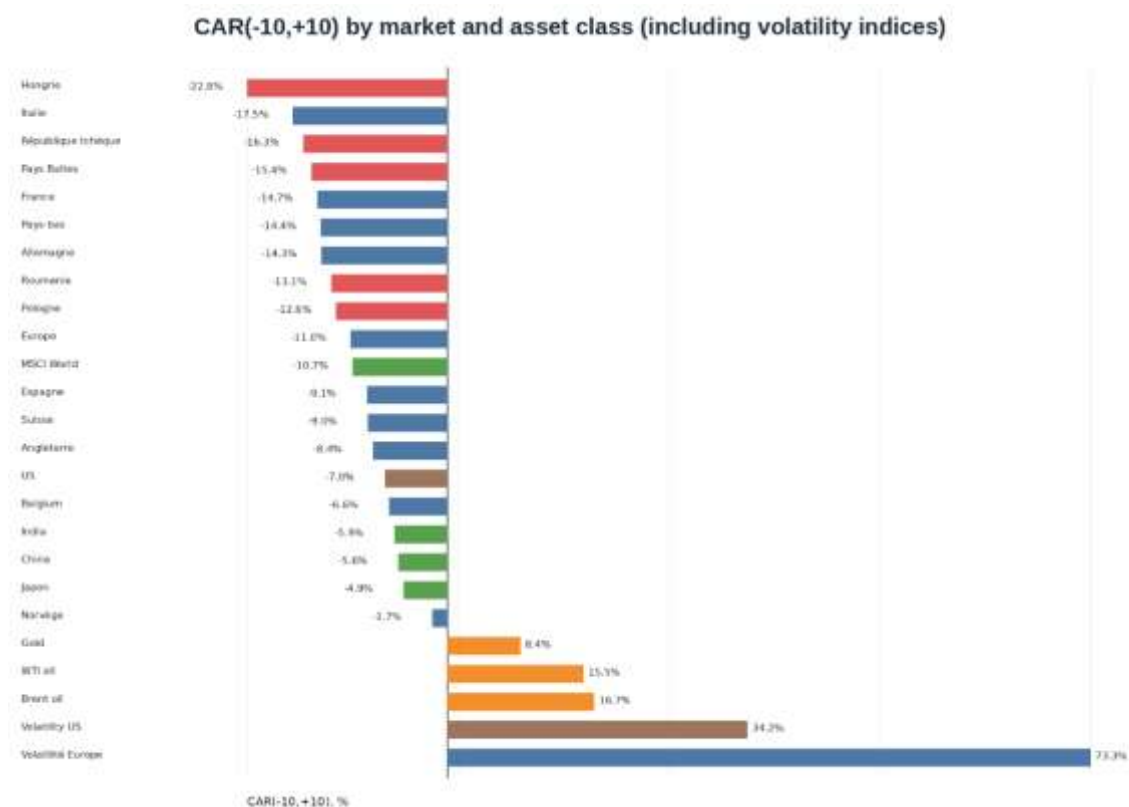
The distribution of significant results shows that the invasion did not affect all global markets in the same way. Most of the significant reactions are found in Europe. Eastern Europe

records the clearest effects. This supports the idea that investors mainly viewed the invasion as a regional risk rather than as the cause of a general fall in global equity markets.

A purely global risk-off reaction would probably have produced stronger abnormal returns in the United States and in developed Asian markets. However, this is not what the results show. The S&P 500 records negative abnormal returns, but the results remain only close to statistical significance. This suggests that the US market was affected more indirectly. The main transmission channels may have included weaker global investor sentiment, rising inflation expectations and changes in expected monetary policy.

The choice of event window also influences the results. The CAR(-1,+1) window measures the immediate market reaction around the invasion date. Only a limited number of markets outside Eastern Europe show a significant reaction during this short period. The largest number of significant results appears in the medium-term windows. This is particularly visible for CAR(-5,+5) and CAR(-10,+10). This indicates that the shock was not fully absorbed on the event day itself. Investors were also pricing subsequent information about sanctions, energy supply, inflation risks and policy responses. The wider CAR(-10,+50) window is useful to capture persistence, but it is also more exposed to confounding factors such as monetary-policy expectations and the broader 2022 inflation shock. (Annexe A3)

Figure 2. CAR(-10,+10) by market and asset class, including volatility indices.



Economic channels identified by the event study

The results can be explained through three main transmission channels. The first is the energy channel. European equity markets recorded negative abnormal returns, while oil prices increased. Europe was highly dependent on Russian energy supplies at the time of the invasion. The risk of supply disruptions raised concerns about higher production costs, stronger inflation and a possible economic slowdown. This helps explain the significant negative CARs observed for France, Germany, Italy and the broader STOXX Europe index over the medium event windows.

The second channel is geographic and geopolitical proximity. Eastern European markets were closer to the conflict and faced greater exposure to regional instability. Hungary, Poland, the Czech Republic, Romania and the Baltic index were therefore more sensitive to changes in geopolitical risk. Hungary and Poland already show significant reactions over the CAR(-1,+1) window. This indicates that investors adjusted their expectations more quickly in these markets than in broader global indices.

The third channel concerns safe-haven demand and supply risk. Commodities did not react in the same way as equity markets because they were affected by different forces. Oil benefited from fears of supply shortages, while other assets may have attracted investors looking for protection against uncertainty. Brent oil and gold produce positive abnormal returns, meaning that the same geopolitical shock generated losses for risk assets, but gains for assets linked to scarcity, energy supply uncertainty or defensive investor behaviour.

Conclusion of event study

Overall, the event study shows that Russia's invasion of Ukraine had a statistically significant effect on several financial markets, but the effect was highly uneven across regions and asset classes. The clearest evidence from equity markets comes from Europe. Eastern Europe records the largest and most persistent abnormal losses. Western European markets also show significant reactions. These effects are particularly visible over the CAR(-5,+5), CAR(-10,+10) and CAR(-10,+50) windows. However, the strongest declines occur in markets that were more directly exposed to the geopolitical tensions and energy consequences of the war.

The results for the United States are weaker. None of the S&P 500 results are significant at the 5% level, although some are close to this threshold. Emerging and Asian markets show a mixed reaction. The MXEF and NIFTY indices record significant negative CARs, while the results for China and Japan are not statistically significant.

Commodities move in the opposite direction to equity markets. Brent oil and gold record significant positive abnormal returns. The rise in oil reflects concerns about energy supply disruptions. The increase in gold is consistent with stronger demand for safe-haven assets during periods of uncertainty.

These results also support the use of GARCH and EGARCH models alongside panel regressions. The event study identifies abnormal returns around the invasion date. However, it does not fully capture how long the increase in volatility lasted or how the shock spread across markets. The additional models can therefore provide a more complete understanding of volatility persistence and the channels through which the conflict affected financial markets

2. Volatility model GARCH and EGARCH:

The GARCH analysis complements the event study by focusing on changes in market volatility. The event study measures abnormal returns around the invasion date. The GARCH models examine the size of the volatility increase and how long it remained present.

The models use daily logarithmic returns from 2015 to 2025. They are also estimated over the shorter 2021–2022 period to provide a closer view of the invasion and its immediate consequences. Several specifications are tested for each index. These include the standard GARCH, GJR-GARCH and EGARCH models. The analysis also considers the Student-t, skewed Student-t and Generalized Error Distribution (GED).

The final model is selected using the Bayesian Information Criterion (BIC). Only models that converge and meet the stationarity conditions are retained. Residual tests are then used to check whether the selected model captures the main volatility patterns in the data.

The thesis will interpretate of the impact score. The comparison below uses the change between the pre-war window and the acute war window after 24 February 2022. The score averages three indicators: the change in conditional volatility, the change in realized volatility and the change in mean absolute returns. A higher value therefore indicates a stronger volatility shock, not necessarily a larger negative price return.

Regional comparison

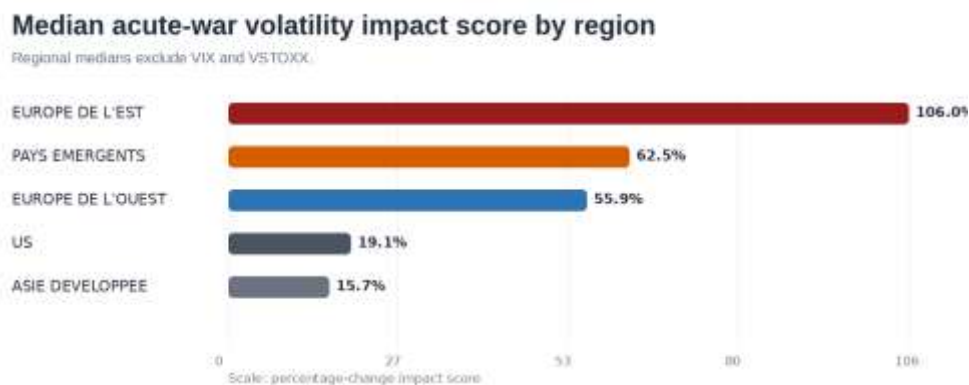
The regional ranking gives the clearest result of the GARCH analysis. Eastern Europe is the most affected group, with a median impact score of 106.0%. This is far above emerging

markets (62.5%) and Western Europe (55.9%). The result is economically coherent: the shock originated in Eastern Europe, increased geopolitical risk in neighboring markets, and created a direct channel through energy prices and regional risk premia.

Table 5. Regional ranking of the acute GARCH volatility impact.

Regional comparison				
Region	Indices	Cond. Vol.	Realized volatility	Impact score
Eastern Europe	5	90.2%	122.4%	106.0%
Emerging country	3	29.8%	90.9%	62.5%
Western Europe	11	30.4%	79.2%	55.9%
US	1	15.7%	17.0%	19.1%
Japan	1	-5.8%	27.9%	15.7%

Figure 3. Regional comparison of median volatility impact scores.



Comparison by index and asset

At the individual level, the strongest reactions are concentrated in Eastern European equities and energy commodities. The five highest impact scores are recorded by Hungary (BUX), Brent oil (CO1 Comdty), Wti oil (CL1 COMB Comdty), Czech Republic (PX Index), Romania (BET Index). Hungary is the clearest equity market case: its conditional volatility increases by 178.5%, realized volatility by 231.2%, and the index falls by 10.3% on the event day. Oil also reacts strongly, but with a different sign in returns: Brent and WTI show high volatility increases while cumulative returns during the acute window are positive, which is consistent with energy supply-risk repricing.

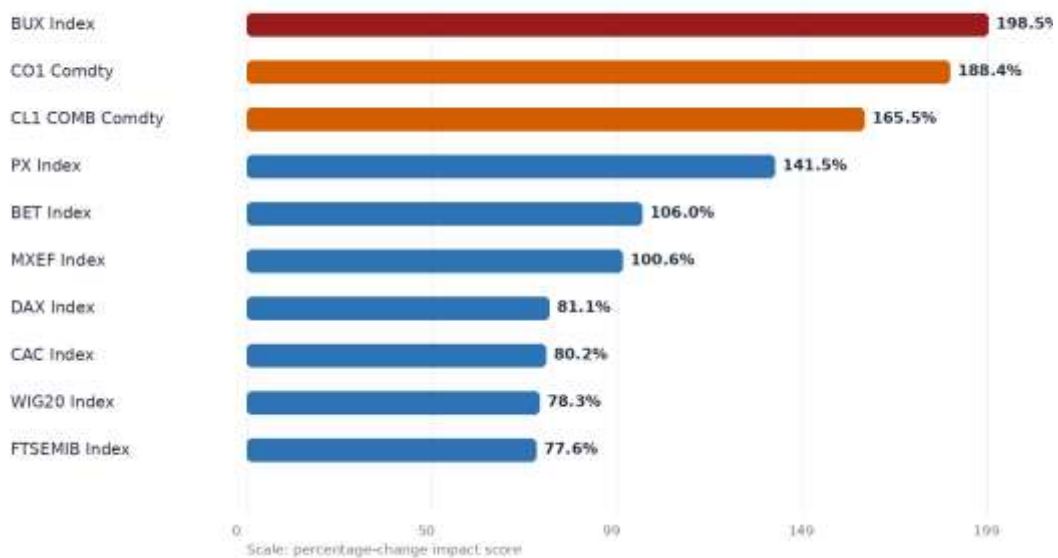
Table 6. Ten most affected indices and assets in the acute war window.

Comparison by index and asset							
Rank	Asset	Country	Region	Class	Cond. vol.	Realized vol.	Score
1	BUX Index	Hungary	Eastern Europe	Equity	178.5%	231.2%	198.5%
2	CO1 Comdty	Brent Oil	Commodity	Commodity	122.8%	237.2%	188.4%
3	CL1 COMB Comdty	WTI oil	Commodity	Commodity	109.6%	200.4%	165.5%
4	PX Index	Czech republic	Eastern Europe	Equity	115.2%	164.0%	141.5%
5	BET Index	Romania	Eastern Europe	Equity	90.2%	122.4%	106.0%
6	MXEF Index	Emerging country	Emerging country	Equity	77.5%	120.6%	100.6%
7	DAX Index	Germany	Western Europe	Equity	45.9%	108.8%	81.1%
8	CAC Index	France	Western Europe	Equity	53.0%	101.4%	80.2%
9	WIG20 Index	Poland	Eastern Europe	Equity	64.8%	100.5%	78.3%
10	FTSEMIB Index	Italia	Western Europe	Equity	47.9%	102.1%	77.6%

Figure 4. Ranking of the ten strongest acute volatility shocks.

Ten largest acute-war volatility impact scores

The impact score combines conditional volatility, realised volatility and mean absolute return changes.



Additional model-selection diagnostics, variance-effect counts and supplementary GARCH figures are reported in Annexe A4. The body of the chapter keeps the two most useful volatility visuals: the regional median impact score and the ranking of the ten strongest acute volatility shocks.

Conclusion of the GARCH analysis

The GARCH results confirm that the invasion of Ukraine produced a concrete volatility shock, but the effect was not uniform across markets. The most affected equity markets are those geographically and economically closest to the conflict, especially Eastern Europe. Western European markets are also clearly affected by the conflict. However, the median volatility impact is lower than in Eastern Europe. The results also vary more across countries. The United States experiences a smaller increase in volatility. This suggests that the conflict reached the US market through more indirect channels. These channels may include changes in global risk sentiment and growing uncertainty rather than direct regional exposure.

Commodities show a different pattern from equity markets. Oil records a particularly strong increase in volatility while also generating positive short-term returns. This reaction reflects concerns about supply shortages and rising energy prices rather than the type of financial stress observed in stock markets.

Overall, the results show that the war had a measurable impact on financial markets through two related channels. The first channel was a decline in abnormal returns across the most exposed equity markets. The second channel was a sharp rise in conditional volatility. This increase was strongest in Eastern Europe and in energy markets.

These findings should still be interpreted with caution. The estimated effects cannot be attributed entirely to the invasion. The year 2022 was also marked by high inflation, changes in monetary policy and major disruptions in energy markets. These developments may have reinforced or partly influenced the results. However, the timing, regional ranking and commodity response make the war channel economically credible.

3. Panel data regression:

The panel data analysis is used as the third empirical step of the thesis. Unlike the event study, which focuses on abnormal returns around a narrow event window, and unlike the GARCH/EGARCH models which study volatility dynamics market by market, the panel regression combines the cross-sectional and time-series dimensions of the dataset. This makes it possible to test whether the regional patterns identified previously remain visible after controlling for market-specific characteristics and common shocks.

The dependent variables are daily log returns and absolute daily log returns for the equity indices included in the sample. The main explanatory variables are the event-day dummy for 24 February 2022, the one-month adjustment window from 25 February to 24 March 2022, and the remaining 2022 adjustment period from 25 March to 31 December 2022. The regressions also include market fixed effects. In the most demanding specification, two-way fixed effects are used, which means that the model controls for both index-specific characteristics and common daily shocks. In that specification, the regional interaction terms measure whether a region behaved differently from the United States and from the common daily market movement.

The panel dataset contains 20 equity indices from Western Europe, Eastern Europe, emerging markets, developed Asia and the United States. VIX, VSTOXX, Brent oil, WTI oil and gold are used as transmission or control variables rather than as dependent variables. This specification is consistent with the role assigned to the panel model in the methodology: it moves the analysis from descriptive comparison toward a more formal cross-market explanation.

The descriptive regional panel table and the corresponding event-day/absolute-return figures are reported in Annexe A5. The body of the chapter therefore focuses on the coefficient table and the two-way fixed-effect event-day figure, which are the most useful elements for testing the hypotheses.

Panel regression results

The first return regression confirms the existence of a statistically significant negative event-day effect. After controlling for index fixed effects and for the main transmission variables, the event-day coefficient is -3.12 percentage points and is statistically significant at the 1% level. The one-month coefficient is not statistically significant, which indicates that the immediate negative return was not mechanically extended into the full month after the invasion. The remaining 2022 adjustment period is negative and significant, but its magnitude is smaller on a daily basis. This suggests that the strongest price reaction occurred immediately, while the following months were affected by a weaker but persistent repricing process.

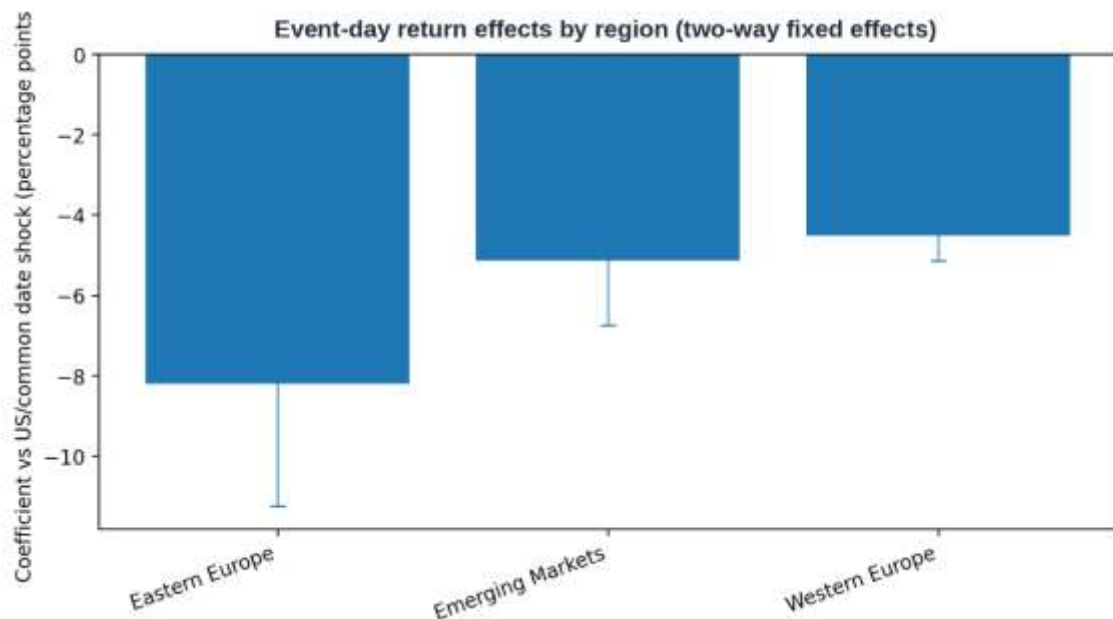
The two-way fixed-effects model provides the clearest evidence on regional heterogeneity. Because common daily shocks are absorbed by date fixed effects, the coefficients should be interpreted as regional deviations relative to the United States and to the market-wide daily shock. Western Europe underperformed by 4.51 percentage points on the event day, Eastern

Europe by 8.21 percentage points, and emerging markets by 5.13 percentage points. All three coefficients are statistically significant at the 1% level. This result strongly supports the interpretation that the invasion was not only a global risk-off event but also a geographically differentiated shock.

Table 7. Main panel-regression coefficients.

Model	Variable	Estimate (p.p.)	Std. error	p-value
Return FE + controls	Event day	-3.12	0.65	<0.001
Return FE + controls	Adjustment 2022	-0.07	0.02	<0.001
Return two-way FE	Western Europe x event day	-4.51	0.32	<0.001
Return two-way FE	Eastern Europe x event day	-8.21	1.55	<0.001
Return two-way FE	Emerging markets x event day	-5.13	0.82	<0.001
Abs. return FE + controls	Event day	3.28	0.59	<0.001
Abs. return FE + controls	One-month window	0.96	0.08	<0.001
Abs. return two-way FE	Eastern Europe x event day	5.27	1.47	<0.001
Abs. return two-way FE	Eastern Europe x one-month	0.80	0.26	0.002

Figure 5. Two-way fixed-effects return impact on the event day.



Interpretation of the panel results

The panel results reinforce the interpretation obtained from the event study and the GARCH/EGARCH models. First, the event-day coefficient in the return model shows that the invasion generated a broad negative equity-market reaction. However, the regional interaction terms show that this reaction was not homogeneous. Eastern Europe is clearly the most affected group, which is consistent with geographical proximity, higher perceived regional risk and stronger exposure to security concerns. Western Europe is also significantly affected, which is coherent with the energy, sanctions, and inflation channels. Emerging markets are affected as well, but their reaction appears less persistent.

Second, the absolute-return regressions confirm that the invasion affected market volatility as well as price levels. The event-day coefficient is positive and statistically significant. The one-month coefficient also remains strongly significant. This shows that market instability continued even after average returns began to recover or became less negative.

The two-way fixed-effects results once again show that Eastern Europe was the most affected region. On the event day, its absolute-return deviation reached 5.27 percentage points. Over the following month, the deviation remained positive at 0.80 percentage points. This result is important because it shows that the regional impact was not limited to falling market prices. It also led to a clear increase in the intensity of financial risk.

Third, the control variables also highlight the role of uncertainty and commodity markets. Changes in the VIX and VSTOXX are strongly significant in both the return and absolute-return regressions. This confirms that equity-market movements were closely linked to global risk aversion and to the rise in European market volatility. Brent and WTI also enter significantly in the return equation, although their signs should be interpreted carefully because energy prices, inflation expectations and investor sentiment moved together during 2022. The panel model therefore supports the role of energy and uncertainty as transmission channels, but it should not be interpreted as a pure causal decomposition of each channel.

The correlation evidence is more cautious. The average pairwise correlation between equity indices are 0.54 before the war and 0.53 during the one-month window. It then decreases to 0.47 during the remaining 2022 adjustment period and 0.41 after 2022. This does not provide strong evidence that the invasion permanently increased average cross-market correlations. The panel evidence therefore supports a regional shock and a volatility shock more strongly than a permanent contagion effect measured through simple correlations. The detailed correlation table is reported in Annexe A5 in order to keep the main empirical chapter focused on the three core dimensions: price reaction, volatility reaction and regional heterogeneity.

Conclusion of the panel data analysis

Overall, the panel data analysis confirms and formalizes the main findings of the previous empirical methods. The invasion of Ukraine produced a statistically significant negative effect on equity returns on 24 February 2022. More importantly, the effect was strongly heterogeneous across regions. Eastern Europe is the most exposed equity region, followed by Western Europe and emerging markets, while the United States is not affected in the same way in the panel specification.

The panel regressions also show that the impact of the invasion was not limited to negative returns. Absolute returns increased significantly on the event day and remained high during the following month. This confirms that the conflict also affected market volatility.

This effect is particularly clear in Eastern Europe. The increase in absolute returns remains significant even after accounting for daily shocks that affected all markets and for the specific characteristics of each index. Eastern European markets therefore experienced a stronger rise in instability than the other regions included in the analysis.

The panel analysis strengthens the overall conclusion of the thesis. It shows that the findings from the event study and the GARCH models are not simply separate results observed for individual markets. The same regional pattern remains visible when all markets are analyzed together within a common econometric framework. Once the data are analyzed in a unified cross-market framework, the same pattern remains visible: the invasion generated a strong regional shock, with the clearest financial stress concentrated in Eastern Europe and a broader but less intense effect in Western Europe and emerging markets.

Cross-method synthesis including panel data

Table 8. Cross-method synthesis including panel data.

Finding	Event study	GARCH/EGARCH	Panel data	Interpretation
Eastern Europe is the most exposed equity region	All five Eastern European markets have at least one significant CAR.	Highest median impact score in the GARCH analysis.	Event-day return deviation of -8.21 p.p.; absolute-return deviation of +5.27 p.p.	Strongly supported.
Western Europe is affected, but less intensely	Many significant CARs, especially over medium windows.	Median volatility impact below Eastern Europe but clearly above the US.	Event-day return deviation of -4.51 p.p.; absolute-return deviation of +1.51 p.p.	Supported.

The United States is less directly exposed	No CAR significant at 5% for SPX.	Lower volatility impact score.	Used as reference group; European and emerging-market deviations are negative relative to it.	Supported.
The shock affected volatility beyond returns	CARs identify abnormal price reactions.	GARCH identifies conditional volatility increases.	Absolute returns increase by +3.28 p.p. on the event day and +0.96 p.p. in the one-month window.	Strongly supported.

Taken together, the three empirical methods provide a coherent interpretation of the Russia-Ukraine invasion. The event study identifies the abnormal price reaction around the shock, the GARCH/EGARCH models show that volatility increased sharply in the most exposed markets, and the panel regression confirms that the same regional pattern remains significant when the markets are analyzed jointly. The evidence is therefore stronger than a simple descriptive comparison because the panel results confirm that Eastern Europe and Western Europe behaved differently from the United States after controlling for market-specific and time-specific effects.

Response to the empirical hypotheses:

Table 9. Response to the empirical hypotheses including panel data.

Hypothesis	Empirical answer	Panel interpretation
H1: European equity markets reacted more strongly than the United States.	Supported.	The panel model confirms that Western Europe and Eastern Europe underperformed the United States on the event day. The two-way fixed-effects coefficients are -4.51 p.p. for Western Europe and -8.21 p.p. for Eastern Europe.
H2: Eastern Europe was the most exposed equity region.	Strongly supported.	Eastern Europe records the largest raw event-day loss, the strongest negative return deviation in the panel model and the largest absolute-return deviation. It is also the only region with a significant one-month absolute-return deviation.
H3: Commodities reacted differently from equities.	Partially supported by the panel analysis;	The panel model includes oil and gold as control variables rather than as dependent variables. It therefore does not directly measure whether commodities performed better than

	supported overall by the full empirical framework.	equity markets. However, the significant coefficients for Brent and WTI show that changes in energy prices played an important role in the transmission of the shock to stock markets. The direct response of commodities is more clearly analyzed through the event study and the GARCH models.
H4: The shock affected volatility beyond price levels.	Strongly supported.	Absolute returns increase significantly on the event day and during the one-month period. The Eastern European absolute-return effect remains significant after controlling for index and date fixed effects.

Final conclusion:

The question research of this thesis was “*How Russia’s invasion of Ukraine on the 24th February 2022 affected global financial markets in terms of abnormal returns, volatility and regional transmission*”. The objective was not only to observe whether stock markets declined after the invasion, but to understand whether the reaction differed across regions, countries and asset classes. To answer this question, the research combined three complementary empirical methods: an event study, GARCH/EGARCH volatility models and panel data regressions.

The main conclusion is that the invasion had a clear and measurable impact on financial markets, but this impact was not homogeneous. In my view, this is the most important result of the thesis. The war did not affect all markets equally. The evidence shows a hierarchy of exposure: Eastern Europe was the most affected equity region, Western Europe was also clearly affected but less severely, the United States reacted more indirectly, emerging and Asian markets showed mixed results, and commodities reacted differently from equities.

Eastern Europe was the most exposed region in the analysis. All five Eastern European markets in the sample recorded at least one statistically significant CAR at the 5% level, with 18 significant event-study observations. The reaction was already visible in the very short window around the invasion: Hungary’s BUX recorded a CAR(-1,+1) of -4.67% with a p-value of 0.009, while Poland’s WIG20 recorded -5.60% with a p-value of 0.004. Hungary was the strongest case, with significant negative CARs across all five event windows, including -22.82% on CAR(-10,+10) and -27.96% on CAR(-10,+50). Poland also showed one of the strongest long-window effects, with WIG20 reaching -28.45% on CAR(-10,+50).

In my opinion, these results show that investors did not only price the invasion as a general global risk-off event. They also priced proximity risk. Countries closer to the conflict were

perceived as more vulnerable to regional instability and security concerns. This is confirmed by the GARCH/EGARCH results: Eastern Europe recorded the highest regional median volatility impact score, at 106.0%, compared with 55.9% for Western Europe and only 19.1% for the United States. At the individual level, Hungary's BUX recorded the highest impact score in the sample, at 198.5%, with conditional volatility increasing by 178.5% and realized volatility by 231.2%. This means that Eastern Europe was affected both through negative returns and through a sharp increase in market risk.

Western Europe was also significantly affected, although less intensely than Eastern Europe. In the event study, 9 out of 11 Western European markets had at least one significant CAR at the 5% level, with 21 significant observations in total. The strongest negative reactions were observed in Italy, France and Germany: FTSEMIB reached -17.52% on CAR(-10,+10), CAC reached -14.75% and DAX reached -14.29%. These results suggest that investors quickly priced the economic consequences of the war for Europe, especially through energy dependence, sanctions, inflation expectations and weaker growth prospects. The panel model supports this interpretation. On the event day, Western Europe underperformed the United States by 4.51 percentage points, while Eastern Europe underperformed by 8.21 percentage points.

The US market was less directly affected. The S&P 500 recorded negative CAR over several event windows, but none of these results reached the 5% significance threshold. The results were only borderline on CAR(-10,+10), with a p-value of 0.064, and on CAR(-10,+50), with a p-value of 0.058. Its GARCH volatility impact score was also much lower, at 19.1%. In my view, this does not mean that the United States was unaffected by the war. Rather, the transmission was more indirect, through global risk aversion, inflation expectations, energy prices and monetary-policy uncertainty, instead of direct geographic or energy exposure.

Emerging and Asian markets showed a more mixed reaction. The MSCI Emerging Markets index recorded a significant CAR(-10,+10) of -10.72%, with a p-value of 0.007, while NIFTY recorded a significant CAR(-5,+5) of -6.97%. However, China and Japan did not show the same level of statistical evidence in the event study. The panel model also shows that emerging markets underperformed the United States by 5.13 percentage points on the event day. I interpret this as evidence that the shock was transmitted outside Europe, but less systematically. Emerging markets were mainly affected through global risk aversion, capital-flow concerns and commodity-price movements.

The commodity results are particularly important because they show that the same geopolitical shock can produce opposite effects across asset classes. While exposed equity

markets generally declined, Brent oil and gold recorded positive abnormal returns. Brent oil showed a significant CAR(-5,+5) of 14.18%, while gold recorded a significant CAR(-10,+10) of 8.36%. The GARCH analysis reinforces this result: Brent oil had an impact score of 188.4%, and WTI oil had an impact score of 165.5%, making them two of the strongest volatility shocks in the sample. In my opinion, this confirms that geopolitical crises do not simply destroy value everywhere; they redistribute risk and value across markets. Oil benefited from supply-risk repricing, while gold benefited from safe-haven demand.

The GARCH/EGARCH results also show that the invasion was not only a price shock, but also a volatility shock. In the focused 2021-2022 sample, EGARCH was selected for 17 out of 25 assets, and the skewed Student-t distribution was selected for 18 out of 25 assets. This supports the idea that market reactions during the crisis were asymmetric and non-normal, with stronger tail risk. The event-day variance effects were significant for 11 out of 24 assets, and all significant event-day effects were increases. This volatility dimension is important because a market can recover part of its price loss while remaining much riskier.

The panel data results provide an additional confirmation of the main findings. The return fixed-effects model shows a negative event-day coefficient of -3.12 percentage points, significant at the 1% level. The absolute-return model shows an event-day increase of 3.28 percentage points, also significant at the 1% level, and a one-month absolute-return increase of 0.96 percentage points. This confirms that the invasion affected both the direction of returns and the intensity of market movements. Eastern Europe again appears as the most vulnerable region, with an event-day absolute-return deviation of 5.27 percentage points and a one-month absolute-return deviation of 0.80 percentage points.

However, the evidence on contagion must be interpreted carefully. The average pairwise correlation between equity indices was 0.538 before the war and 0.531 during the one-month period after the invasion. It then decreased to 0.469 during the rest of 2022 and to 0.412 after 2022. Therefore, I would not conclude that the invasion created a permanent increase in global equity-market correlations. A more accurate interpretation is that the war generated regional financial stress with international spillovers, rather than strong and lasting global contagion.

Overall, the four hypotheses are supported to different degrees. European equity markets reacted more strongly than the United States, and Eastern Europe was clearly the most exposed equity region. Commodities reacted differently from equities, with Brent oil and gold recording positive abnormal returns while many equity indices declined. Finally, the shock

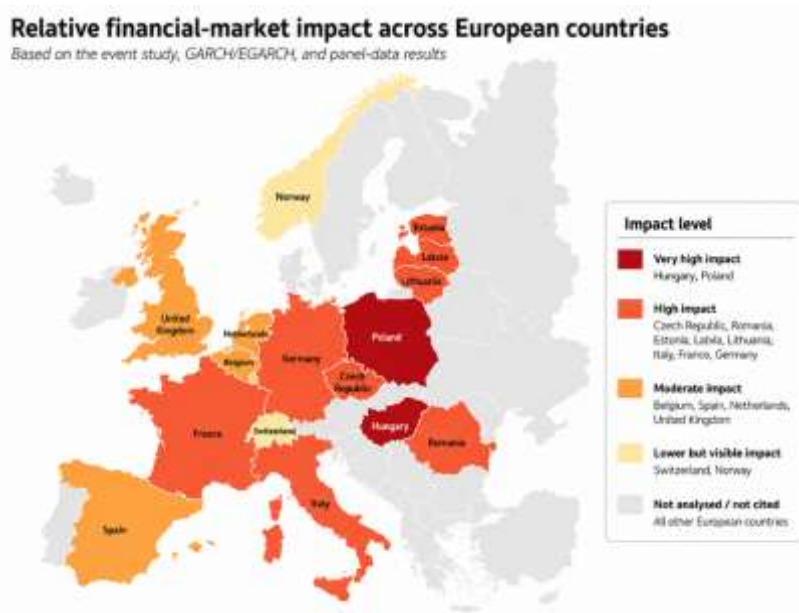
affected volatility beyond price levels, as shown by the GARCH/EGARCH impact scores and by the panel regressions on absolute returns.

My overall view is that the Russia-Ukraine invasion should be understood as a differentiated geopolitical-financial shock rather than a uniform global market crash. The strongest effects appeared where the economic and geopolitical exposure was greatest. Eastern Europe was affected through proximity and security risk, Western Europe through energy dependence and inflation expectations, emerging markets through risk aversion and capital-flow channels, and commodities through supply-risk and safe-haven mechanisms.

From a practical perspective, I would propose three main lessons. First, investors should integrate geopolitical exposure more explicitly into portfolio risk management, because geographic diversification is not sufficient if several markets are exposed to the same energy or regional-risk channel. Second, European policymakers should treat energy dependence as a financial-stability issue, not only as an industrial or political issue. Third, future research should extend this analysis to sectors such as banks, energy-intensive industries, utilities, defense and consumer sectors, because the impact of the war was probably very different across industries.

This thesis therefore shows that geopolitical shocks must be analyzed through several complementary methods. The event study identifies abnormal returns, GARCH/EGARCH models capture volatility dynamics, and panel regressions confirm regional heterogeneity. Taken together, the results show that Russia's invasion of Ukraine had a significant financial impact, especially in Europe and energy-related assets, but that this impact was selective, uneven and strongly dependent on each market's exposure to the conflict.

Figure 6. European map of the impact by country.



Source:

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ANNEXES:

Annexe A1. Detailed event-study table: statistically significant CAR.

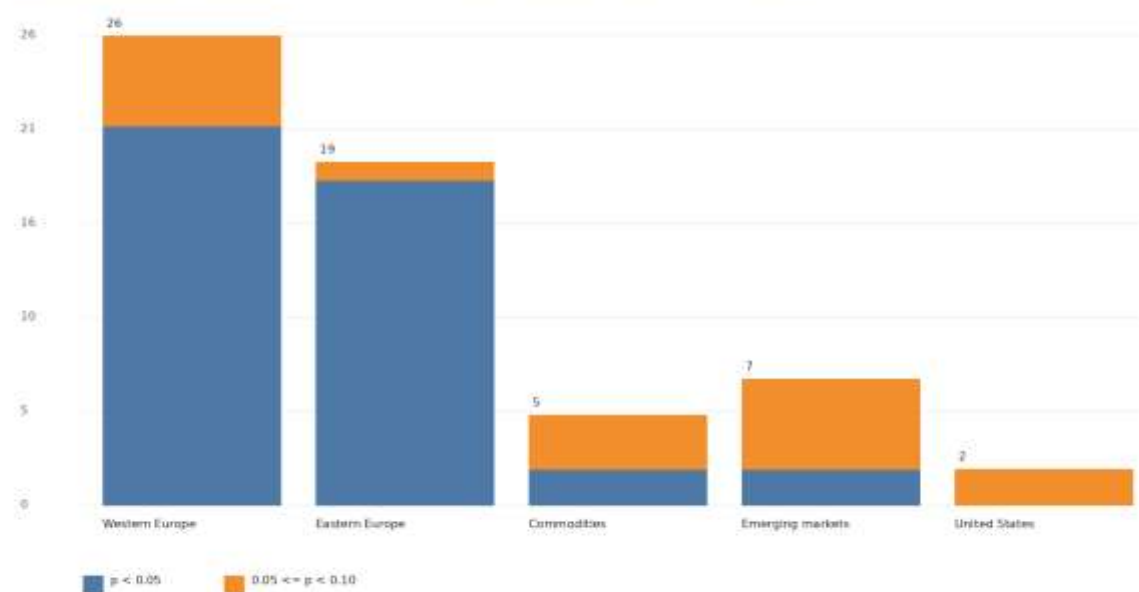
Significant 5% (p-value < 0.05)					
Index	Market	Window	CAR	t-stat	p-value
SXXP index	Western Europe	CAR(-5,+5)	-7,12%	-2,6250	0,92%
SXXP index	Western Europe	CAR(-10,+10)	-10,98%	-2,9277	0,38%
SXXP index	Western Europe	CAR(-10,+50)	-15,12%	-2,3651	1,89%
CAC index	Western Europe	CAR(-5,+5)	-9,37%	-3,0244	0,28%
CAC index	Western Europe	CAR(-10,+10)	-14,75%	-3,4444	0,07%
CAC index	Western Europe	CAR(-10,+50)	-19,45%	-2,6660	0,82%
DAX index	Western Europe	CAR(-5,+5)	-11,73%	-3,7076	0,03%
DAX index	Western Europe	CAR(-10,+10)	-14,29%	-3,2695	0,12%
DAX index	Western Europe	CAR(-10,+50)	-16,21%	-2,1760	3,06%
BEL20 index	Western Europe	CAR(-5,+5)	-5,92%	-2,3414	2,01%
IBEX index	Western Europe	CAR(-5,+5)	-8,62%	-2,5868	1,03%
FTSEMIB Index	Western Europe	CAR(-5,+5)	-12,27%	-3,6432	0,03%
FTSEMIB Index	Western Europe	CAR(-10,+10)	-17,52%	-3,7660	0,02%
FTSEMIB Index	Western Europe	CAR(-10,+50)	-20,12%	-2,5369	1,18%
AEX index	Western Europe	CAR(-5,+5)	-7,78%	-2,5389	1,18%
AEX index	Western Europe	CAR(-10,+10)	-14,37%	-3,3930	0,08%
AEX index	Western Europe	CAR(-10,+50)	-17,17%	-2,3784	1,82%
SMI index	Western Europe	CAR(-5,+5)	-4,78%	-2,0125	4,53%
SMI index	Western Europe	CAR(-10,+10)	-9,02%	-2,7506	0,64%
UKX index	Western Europe	CAR(-5,+5)	-5,41%	-2,1136	3,56%
UKX index	Western Europe	CAR(-10,+10)	-8,39%	-2,3696	1,86%
BUX Index	Eastern Europe	CAR(-1,+1)	-4,67%	-2,6181	0,94%
BUX Index	Eastern Europe	CAR(-5,+5)	-20,93%	-6,1276	0,00%
BUX Index	Eastern Europe	CAR(-10,+10)	-22,82%	-4,8362	0,00%
BUX Index	Eastern Europe	CAR(-20,+20)	-17,13%	-2,5970	1,00%
BUX Index	Eastern Europe	CAR(-10,+50)	-27,96%	-3,4760	0,06%
WIG20 index	Eastern Europe	CAR(-1,+1)	-5,60%	-2,9193	0,39%
WIG20 index	Eastern Europe	CAR(-5,+5)	-9,15%	-2,4918	1,34%
WIG20 index	Eastern Europe	CAR(-10,+10)	-12,63%	-2,4882	1,36%
WIG20 index	Eastern Europe	CAR(-10,+50)	-28,45%	-3,2895	0,12%
PX index	Eastern Europe	CAR(-5,+5)	-7,12%	-3,1920	0,16%
PX index	Eastern Europe	CAR(-10,+10)	-16,33%	-5,2946	0,00%
PX index	Eastern Europe	CAR(-20,+20)	-9,61%	-2,2294	2,68%
PX index	Eastern Europe	CAR(-10,+50)	-19,72%	-3,7514	0,02%
BET index	Eastern Europe	CAR(-5,+5)	-11,06%	-4,3680	0,00%
BET index	Eastern Europe	CAR(-10,+10)	-13,15%	-3,7576	0,02%
BET index	Eastern Europe	CAR(-10,+50)	-14,67%	-2,4601	1,46%
OMXBBGI index	Eastern Europe	CAR(-5,+5)	-11,00%	-3,2855	0,12%
OMXBBGI index	Eastern Europe	CAR(-10,+10)	-15,41%	-3,3311	0,10%
MXEF index	Emerging market	CAR(-10,+10)	-10,72%	-2,7273	0,69%
NIFTY Index	Emerging market	CAR(-5,+5)	-6,97%	-2,2249	2,71%
CO1 Comdty	Commodity	CAR(-5,+5)	14,18%	2,1194	3,51%
XAU BGNL Curncy	Commodity	CAR(-10,+10)	8,36%	2,2259	2,70%

Annexe A2. Dataset used for Figure 1: CAR(-10,+10) by market and region.

Index	Market	Window	CAR	t-stat	p-value	Significant
SXXP index	Western Europe	CAR(-10,+10)	-10,98%	-2,928	0,004	TRUE
CAC index	Western Europe	CAR(-10,+10)	-14,75%	-3,444	0,001	TRUE
DAX index	Western Europe	CAR(-10,+10)	-14,29%	-3,270	0,001	TRUE
BEL20 index	Western Europe	CAR(-10,+10)	-6,58%	-1,883	0,061	FALSE
IBEX index	Western Europe	CAR(-10,+10)	-9,06%	-1,969	0,050	FALSE
FTSEMIB Index	Western Europe	CAR(-10,+10)	-17,52%	-3,766	0,000	TRUE
AEX index	Western Europe	CAR(-10,+10)	-14,37%	-3,393	0,001	TRUE
SMI index	Western Europe	CAR(-10,+10)	-9,02%	-2,751	0,006	TRUE
UKX index	Western Europe	CAR(-10,+10)	-8,39%	-2,370	0,019	TRUE
V2X index	Western Europe	CAR(-10,+10)	73,34%	1,744	0,083	FALSE
BUX Index	Eastern Europe	CAR(-10,+10)	-22,82%	-4,836	0,000	TRUE
WIG20 index	Eastern Europe	CAR(-10,+10)	-12,63%	-2,488	0,014	TRUE
PX index	Eastern Europe	CAR(-10,+10)	-16,33%	-5,295	0,000	TRUE
BET index	Eastern Europe	CAR(-10,+10)	-13,15%	-3,758	0,000	TRUE
OMXBBGI index	Eastern Europe	CAR(-10,+10)	-15,41%	-3,331	0,001	TRUE
MXEF index	Emerging market	CAR(-10,+10)	-10,72%	-2,727	0,007	TRUE
SHCOMP Index	Emerging market	CAR(-10,+10)	-5,56%	-1,391	0,166	FALSE
NIFTY Index	Emerging market	CAR(-10,+10)	-5,94%	-1,371	0,172	FALSE
NKY	Emerging market	CAR(-10,+10)	-4,95%	-0,905	0,366	FALSE
SPX index	US	CAR(-10,+10)	-7,01%	-1,860	0,064	FALSE
VIX	US	CAR(-10,+10)	34,20%	0,853	0,395	FALSE
CO1 Comdty	Commodity	CAR(-10,+10)	16,70%	1,806	0,072	FALSE
CL1 COMB Comdty	Commodity	CAR(-10,+10)	15,51%	1,503	0,134	FALSE
XAU BGNL Curncy	Commodity	CAR(-10,+10)	8,36%	2,226	0,027	TRUE

Annexe A3. Distribution of significant and borderline event-study observations by region.

Significant and borderline event-study observations by region

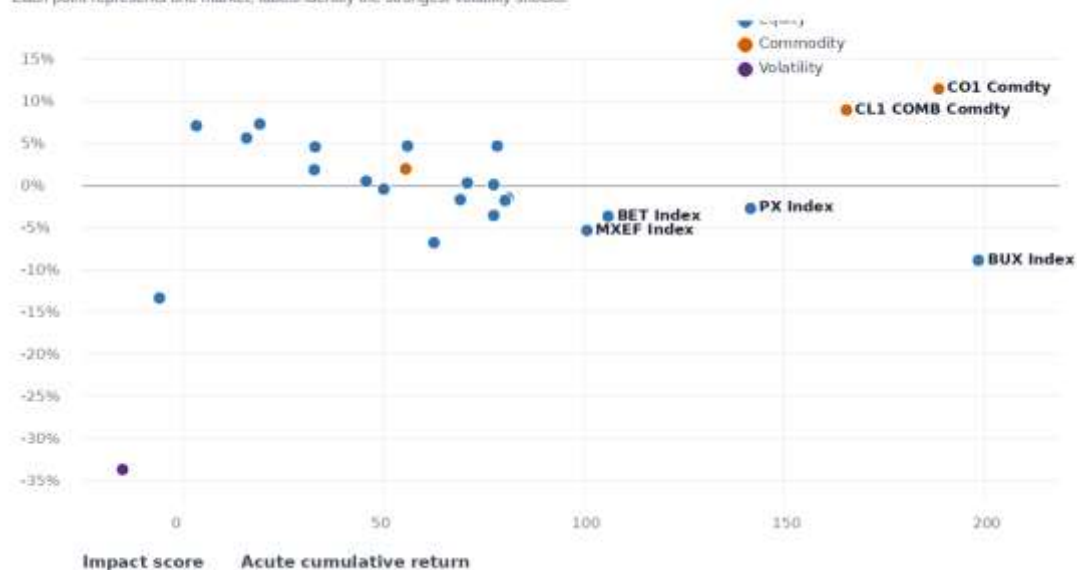


Annexe A4. Supplementary GARCH/EGARCH diagnostics and additional volatility figures

Annexe A4.1. Supplementary heterogeneity between volatility impact and acute cumulative returns.

Volatility impact score versus acute-period cumulative return

Each point represents one market; labels identify the strongest volatility shocks.



Model evidence and robustness

The selected specifications support the use of asymmetric volatility models. EGARCH is selected for 17 of the 25 assets in the focused 2021-2022 sample and for 18 of the 25 assets in the full 2015-2025 sample. The skewed Student-t distribution is also dominant in the focused sample (18 of 25 assets), which indicates that the return distributions are not normally distributed and that tail risk matters during the crisis period.

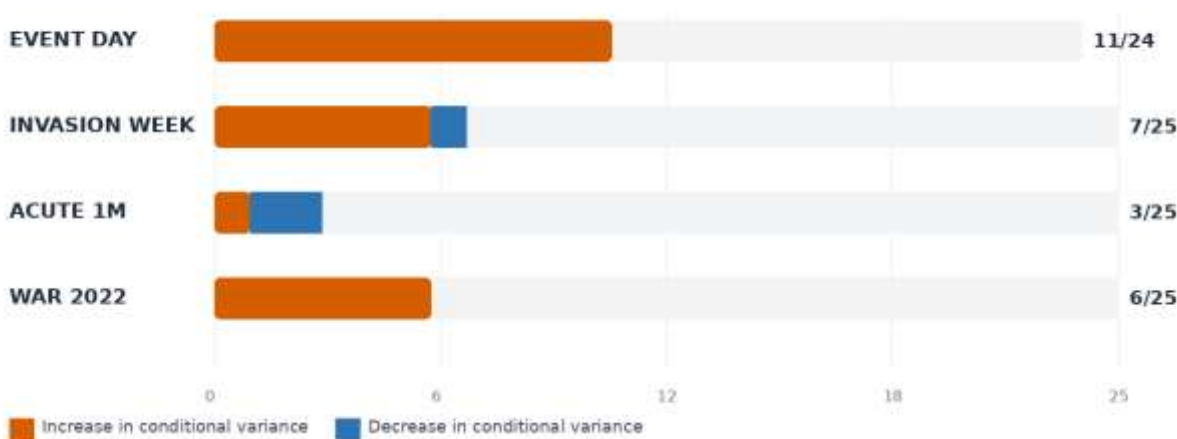
Annexe A4.2. Significant GARCH variance effects in the focused 2021-2022 sample.

Window	Significant	Increase	Decrease	Reading
EVENT DAY	11/24	11	0	Immediate volatility shock
INVASION WEEK	7/25	6	1	Short-term repricing
ACUTE 1M	3/25	1	2	More selective persistence
WAR 2022	6/25	6	0	Persistent but uneven effect

Annexe A4.3. Number and direction of statistically significant variance effects.

Statistically significant GARCH variance effects by event window

Focused 2021-2022 sample, 5% significance threshold.



Annexe A4.4. Additional GARCH interpretation tables and figures.

Rank	Region	Indices	Median cond. vol.	Median realized vol.	Median impact score
1	Eastern Europe	5	90.2%	122.4%	106.0%
2	Emerging markets	3	29.8%	90.9%	62.5%
3	Western Europe	11	30.4%	79.2%	55.9%
4	United States	1	15.7%	17.0%	19.1%
5	Developed Asia	1	-5.8%	27.9%	15.7%

The GARCH and EGARCH results show that the invasion affected both returns and market risk. In the 2021–2022 sample, EGARCH is selected for 17 of the 25 assets. The skewed Student-t distribution is selected for 18 assets. This suggests that negative and positive shocks did not have the same effect on volatility. It also shows that returns were not normally distributed during the crisis.

The reaction was therefore not limited to falling prices. Volatility increased and extreme market movements became more likely.

The regional ranking is consistent with the event-study results. Eastern Europe records the highest median impact score at 106.0%. This confirms that the strongest volatility effects were concentrated in the markets closest to the conflict.

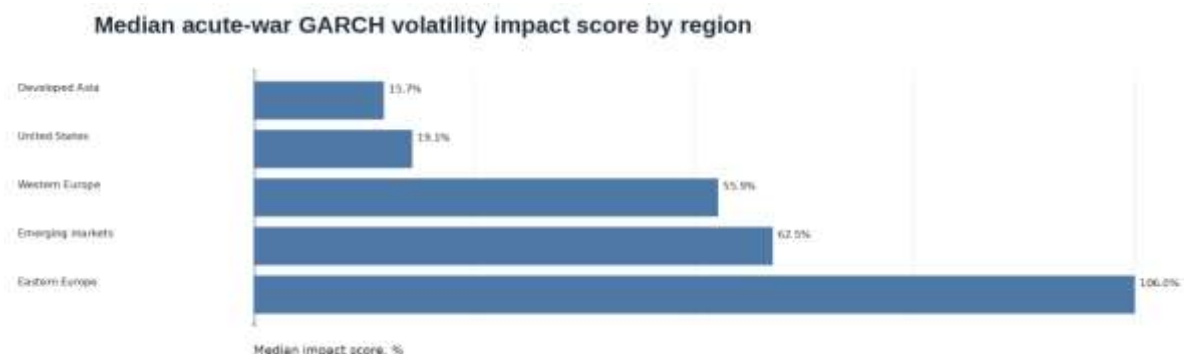
Western Europe was also clearly affected, with a median impact score of 55.9%. However, the impact was weaker and less consistent across countries. The United States recorded a much lower score of 19.1%. This suggests that the US market was mainly affected through broader global uncertainty rather than direct exposure to the war.

Rank	Asset	Region	Cond. vol.	Realized vol.	Score	Event-day return
1	BUX Index	Eastern Europe	178.5%	231.2%	198.5%	-10.27%
2	CO1 Comdty	Commodities	122.8%	237.2%	188.4%	2.29%
3	CL1 COMB Comdty	Commodities	109.6%	200.4%	165.5%	0.77%
4	PX Index	Eastern Europe	115.2%	164.0%	141.5%	-4.89%
5	BET Index	Eastern Europe	90.2%	122.4%	106.0%	-4.17%
6	MXEF Index	Emerging markets	77.5%	120.6%	100.6%	-4.40%
7	DAX Index	Western Europe	45.9%	108.8%	81.1%	-4.04%
8	CAC Index	Western Europe	53.0%	101.4%	80.2%	-3.90%

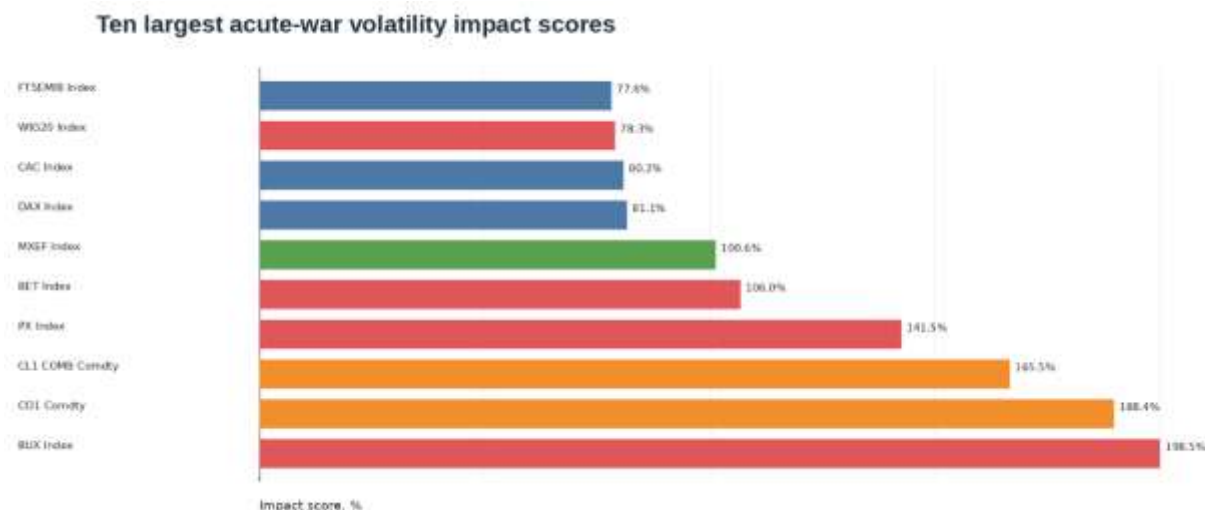
At the asset level, the largest volatility increases are observed in Hungary, Brent oil, WTI oil, the Czech Republic and Romania. This ranking is consistent with the main channels identified in the analysis. Some markets were strongly affected because of their proximity to the conflict. Others were affected by the disruption of global energy markets.

Oil provides a particularly important example. A strong increase in volatility does not always lead to negative returns. Brent and WTI became much more volatile during the acute phase of the crisis, but both recorded positive returns. This confirms that commodities reacted differently from equity markets. While stock markets were mainly affected by uncertainty and weaker growth expectations, oil prices increased because investors feared supply shortages.

Annexe A4.5. Supplementary regional GARCH volatility impact figure.



Annexe A4.6. Supplementary figure: ten strongest acute volatility shocks.



Annexe A5. Supplementary panel-data descriptive evidence and correlation table

Regional descriptive evidence

The regional descriptive statistics show that the impact of the invasion differed widely across markets. European and emerging markets recorded clear losses on the event day. The United States moved in the opposite direction and posted a positive return.

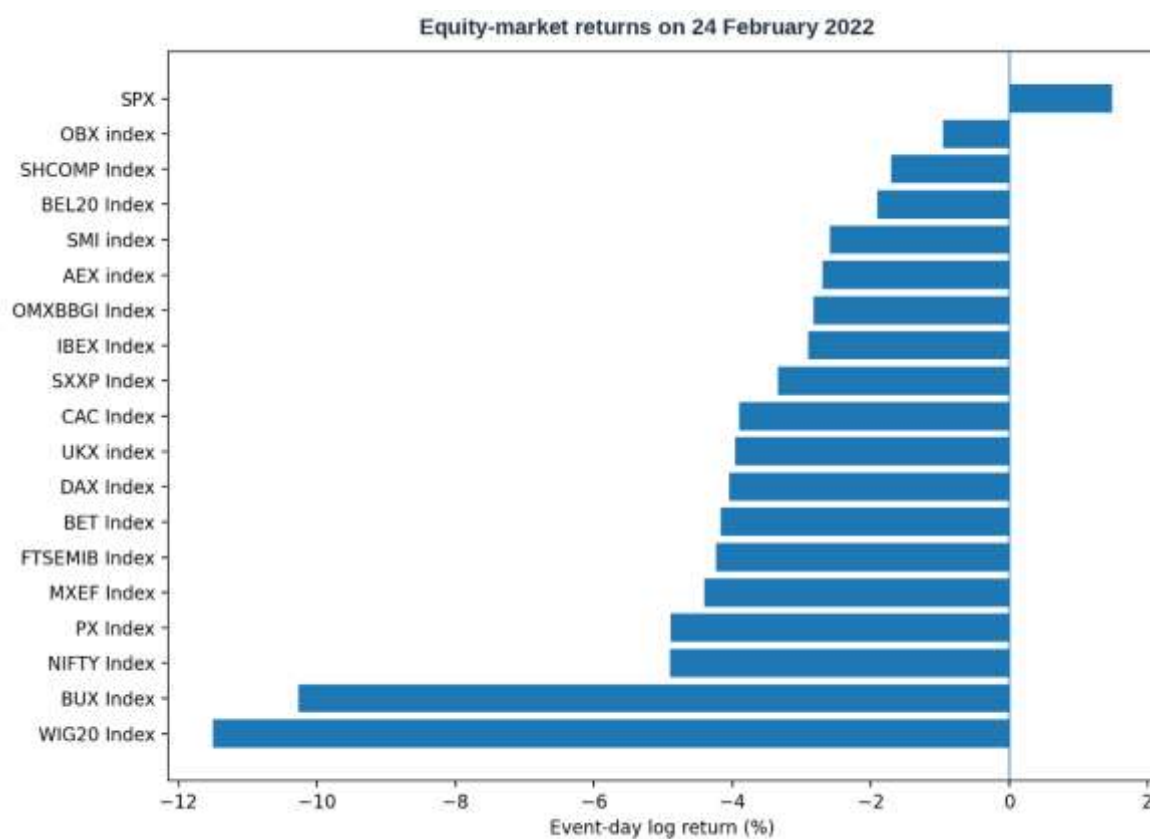
Eastern Europe was the most affected region, with an average event-day return of -6.73%. Emerging markets followed with -3.67%, while Western Europe recorded an average return of -3.05%.

The one-month results do not show a continued decline in average returns across all regions. However, absolute returns increased strongly during this period. This effect was particularly clear in Eastern Europe. The initial fall in prices was therefore followed by a period of greater market instability rather than by a steady continuation of losses.

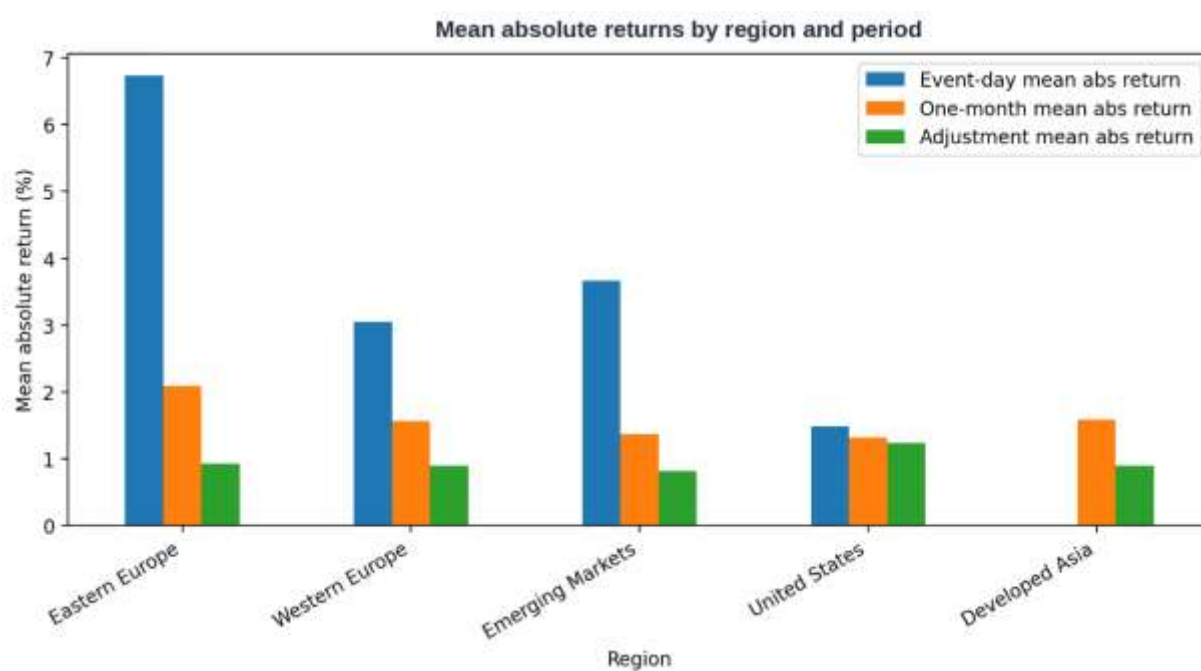
Annexe A5.1. Regional panel comparison.

Region	Event-day return	Event-day abs. return	One-month return	One-month abs. return	Adjustment abs. return
Eastern Europe	-6.73%	6.73%	0.15%	2.09%	0.92%
Western Europe	-3.05%	3.05%	0.13%	1.56%	0.90%
Emerging Markets	-3.67%	3.67%	0.02%	1.37%	0.81%
United States	1.48%	1.48%	0.26%	1.32%	1.24%
Developed Asia	n.a.	n.a.	0.36%	1.58%	0.90%

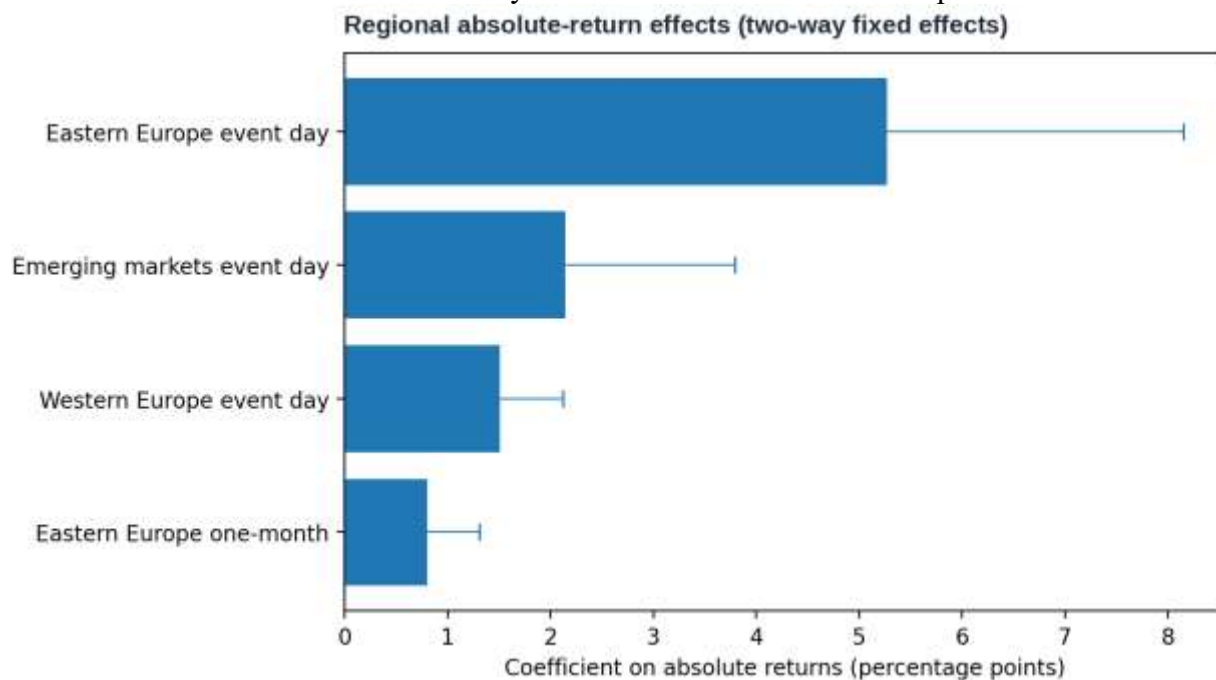
Annexe A5.2. Event-day returns on 24 February 2022.



Annexe A5.3. Mean absolute returns by region and period.



Annexe A5.4. Two-way fixed-effects absolute-return impact.

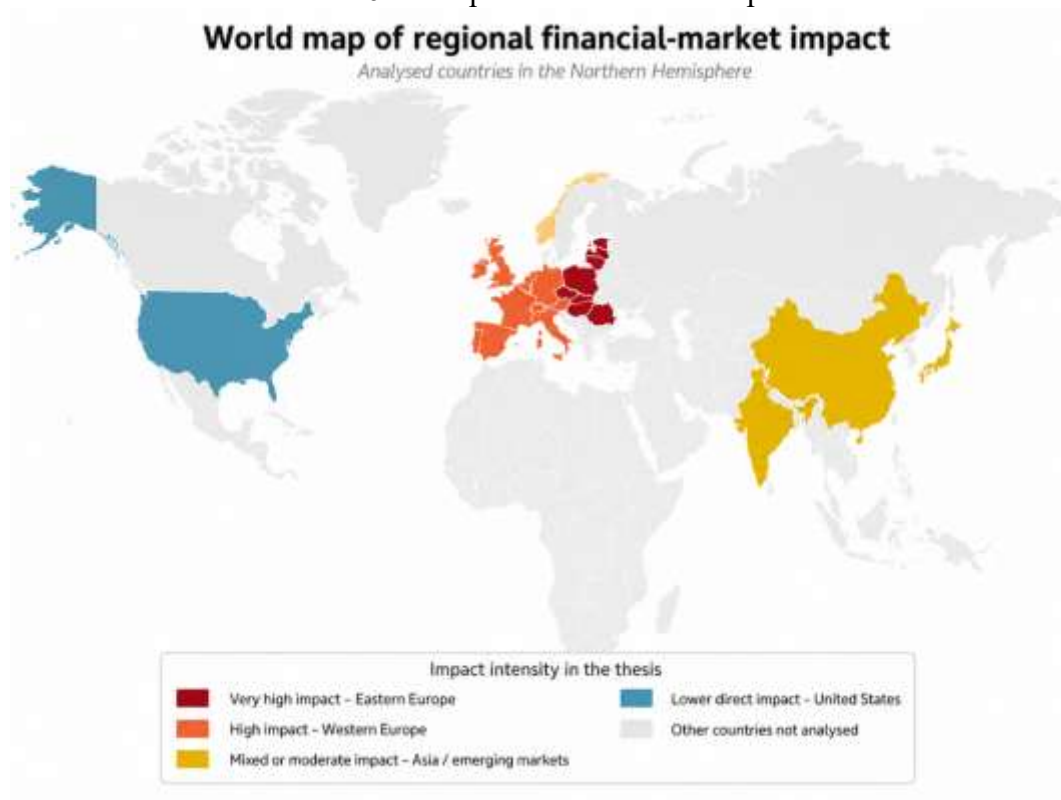


Annexe A5.5. Average pairwise correlations by period.

Period	Average pairwise correlation	Observations
Pre-war	0.538	35104
Event day	n.a.	19
One-month	0.531	391
Adjustment 2022	0.469	3822
Post-2022	0.412	14633

Annexe A.6 : conclusion

Annexe A6.1. Graph about countries impacted



Annexe A6.2. Graph about European countries impacted

