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ORIGINAL PAPER

Economic policy uncertainty, geopolitical risk, market sentiment, and regional stocks: asymmetric analyses of the EU sectors

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Abstract

The purpose of this study is to investigate the asymmetric effects of economic policy uncertainty (EPU), geopolitical risk (GPR), and market sentiment (VIX) on European Union (EU) stocks by sectors of economic activity. The design and methodological approach of our research are rooted in parametric and nonparametric quantile-based techniques. We employ monthly data covering eleven sectors of economic activity in addition to GPR, Global EPU, European Union EPU, United States EPU, and VIX. Our dataset covers the period between February 2013 and September 2022. Our findings show a generally low predictive power of the considered EPU measures on the stock returns of the EU sectors. Notwithstanding, the analysis reveals that EPU from the EU has the highest predictive ability on the EU sectoral stock returns while EPU from the US has no significant predictive ability on the stock returns from the EU. Our findings also highlight the asymmetric effects of various EPUs on EU stocks. Moreover, certain sectoral exposure to EU stocks, found to serve just as diversifiers in normal market conditions, could become a hedge and safe-haven against GPR in extreme economic conditions. Our findings also highlight the role of the VIX as a good gauge to hedge against the downside risks of the EU stocks. The originality of our work is two-fold. First, we extend the study of how global factors influence the EU stock market to the most recent period including the Russia–Ukraine conflict. Second, we perform this study on a sectoral basis. Therefore, the value of our findings is that they provide notable implications for market regulation and portfolio management.

Keywords Geopolitics · Economic policy · Risk and uncertainty · Investor sentiment · Quantile analysis · European Union · Stock market

JEL Classification C32 · C58 · G01 · G10 · G11

Extended author information available on the last page of the article

1 Introduction

Due to their importance to market participants and policymakers, studies that seek to understand the driving factors of stock market returns remain topical in the landscape of financial market research. Evidence points to the fact that global factors, comprising policy uncertainty and geopolitical risk, significantly influence investor sentiment and are pivotal to financial markets (Bossman et al., 2023a; Mensi et al., 2023a, 2023b; Naeem et al., 2021; Xiao et al., 2018). In regional and global financial markets, investment decisions taken by market participants are significantly influenced by economic policies (Dash et al., 2021). Elevated levels of policy instability and/or uncertainty could delay decisions and result in negative outcomes not only for economic agents but also for the world economy in general (Julio & Yook, 2012). Moreover, the price dynamics in financial markets are influenced by changes in investors' sentiment and geopolitical risk, all of which affect and are affected by fiscal and monetary policies and government stimuli that alter the economic environment (Agyei et al., 2021, 2022b; Bossman et al., 2023b).

The above-cited studies provide evidence that there exists an intricate interplay between economics, geopolitics, market sentiment and the performance of stock markets (see also Albaity et al., 2023; Klement, 2021; Shen & Hong, 2023). Therefore, before framing our work within the extant body of knowledge, we present herein a solid theoretical grounding of the research question we address, which concerns establishing a potential link between the global driving factors and European Union (EU) sectoral stocks. Among these factors, we have economic policy uncertainty (EPU), geopolitical risk (GPR), and market sentiment gauged by the Chicago Board Options Exchange's CBOE Volatility Index (VIX). In respect of EPU's influence on EU equity markets, we argue that this linkage might be explained by considering an equity investor as an economic agent who takes the risks of an investment in stocks, expecting to be fairly compensated for bearing those risks. Therefore, an increase in uncertainty of economic policies should negatively affect precision in estimates of both, risk and return, and make the investor's risk aversion augment. As economic policies differ between distinct regions and sectors of economic activities, it is expectable that the same level of EPU at the global or the EU level would not affect in the same way different sectors and industries. This reasoning helps further justify the addressed herein question regarding EPU's impact on EU stocks per sector of economic activity.

In what concerns GPR, a country's and/or region's geography defines in major proportions what weaknesses it may face and what opportunities it should be prepared to catch (Bergesen & Suter, 2018; Klement, 2021; Scholvin, 2016; Scholvin & Wigell, 2018). For instance, out of the great investors' concerns of the current century, almost all, except the Covid-19 pandemic, are geopolitical in their nature. E.g., the globalization narrative at the beginning of century XXI is clearly linked to China and its growing influence in the world economy. In its turn, the subprime crisis has its roots in the US. The US also give origins to the quantitative easing and the low-interest risk environment during the second

decade of the century. Next, the China–US trade war, which has been developing since 2018 onwards, is clearly linked to the geography, economy and politics of these two countries. Finally, the still ongoing since February 2022 military hostilities between Russia and Ukraine is another example of geopolitical risk events (Bossman & Gubareva, 2023; Bossman et al., 2023a, 2023b; Shen & Hong, 2023; Yousaf et al., 2022b). All the above-mentioned episodes have had their particular impacts on the performance of the stock markets around the world, which have differed across countries and geographies. In particular, due to its neighboring geographic location to the Russia–Ukraine conflict, EU economies and financial markets are relatively vulnerable to the conflict-triggered increases in GPR and, hence, the nexus between GPR and the EU stocks requires being addressed more deeply and more extensively (Bedowska-Sojka et al., 2022; Bossman & Gubareva, 2023; Boungou & Yatié, 2022; Yousaf et al., 2022b). This argument provides further justification for the question regarding the linkage between GPR and EU stock market performance.

Now, we succinctly describe the *rationale* for global market sentiment to be considered as a performance driver for EU stock markets. First, we explain what VIX is and what it is supposed to measure. The CBOE Volatility Index, or VIX, projects the probable range of immediate future changes in the US stock markets, above and below their current level. As VIX reaches its highest levels when the equity market is most unsettled, investors, academic scholars, and market participants tend to refer to VIX as a fear gauge. In this sense, VIX is a measure of global market sentiment. As such, several studies have investigated the causal influence of VIX on the European stock indices' behavior (Bosssman et al., 2023a; Li et al, 2020; Magner et al., 2021). The general conclusion of these works is that VIX exhibits remarkable predictive ability for certain European stock markets during, at least since the Covid-19 outbreak onwards. Following this way of thinking, we decide to explore the theoretically expected and experimentally corroborated linkage between global market sentiment and the EU stock market, but now, on a per-sector basis. After having provided the above-developed succinct justification, which offers a fair theoretical grounding to our reasoning that is aligned with the previous literature (see, e.g., Albaityet al., 2023), we indulge in framing our research within the landscape of contemporaneous knowledge, generated along the strands corresponding to the global driving factors analyzed herein.

In particular, it is widely known that the impact of economic policy uncertainty (EPU) on asset values might manifest itself in a variety of ways. First, any uncertainty surrounding economic policies may cause enterprises and other economic players to modify or postpone crucial decisions such as consumption, saving, investment, and employment (Gulen & Ion, 2016). Second, EPU, by impacting both supply and demand mechanisms, might cause financing and production costs to grow and, finally, result in increased disinvestment and contraction of the overall economy (Julio & Yook, 2012). Third, policy uncertainty may raise risks in financial markets by lowering the value of government-provided market safeguards (Pástor & Veronesi, 2012). Finally, inflation, interest rates, and estimated risk premiums could also be impacted by policy uncertainty (Gubareva, 2021a; Rebucci et al., 2022).

In financial economics research, the discourse on the impact of EPU has received increasing attention following the 2007–2008 global financial crisis, during which investors and regulators were concerned about the possible negative implications of economic policies on stock market performance (Arouri et al., 2016). An important opportunity to reassess the impact of EPU on stock market performance newly arises in 2020 within the COVID-19 pandemic setup (Yousaf et al., 2023). In its turn, the currently unfolding military conflict between Russia and Ukraine also represents a challenge for geopolitics as it has substantially amplified geopolitical risks (Bossman & Gubareva, 2023; Bossman et al., 2023a, 2023b). Common to these unprecedented events, the degree of change in economic policies, targeted at curbing the externalities, has been noted to be essential for withstanding financial turbulences transversal to diverse capital markets.

The COVID-19 pandemic, for instance, has been noted to have caused significant changes to the dynamics in bond markets (Bossman et al., 2022a; Gubareva & Umar, 2020; Gubareva, 2021a, 2021b; Gubareva et al., 2023b), traditional and digital currency markets (Bossman et al., 2023b, 2023c; Mensi et al., 2023a; Narayan et al., 2020; Umar & Gubareva, 2020; Wang & Park, 2021; Yousaf et al., 2022a), faith-based assets (Bossman, 2021; Bossman et al., 2022a, 2022b, 2023c; Umar & Gubareva, 2021a), interest rates (Gupta et al., 2021; Umar et al., 2022a, 2022b), commodities (Hanif et al., 2023; Umar et al., 2021), and sustainable stocks (Akhtaruzzaman et al., 2022; Gubareva et al., 2023a; Umar & Gubareva, 2021b; Umar et al., 2021). Common to these studies, cross-asset and cross-market connectedness as well as comovement patterns are significantly modified in the turbulent periods of the pandemic. The underlying reason for such significant changes in financial markets has been attributed to the introduction of unexpected economic policies, targeted at curbing the spread of the pandemic and limiting its consequences on the global economy. Such elevated levels of policy uncertainty and market sentiment instability make investors look for safe-haven and hedge assets, thereby, altering market connectedness (Agyei et al., 2022a; Bossman et al., 2022d; Gubareva et al., 2023b; Hung & Vo, 2021; Mensi et al., 2023a, 2023b).

Similarly, several consecutive packages of sanctions against Russia and those that support it in its illegal aggression against Ukraine have heavily impacted the Russian economy, exacerbating cross-market and cross-asset connectedness (Bossman & Gubareva, 2023; Bossman et al., 2023a, 2023b). As a result, the relationship between geopolitical risk and financial markets has received a great deal of attention. Through the event study analysis, various financial markets have been found to have sensibly responded to Russia's invasion of Ukraine (Sun et al., 2022; Yousaf et al., 2022b). Furthermore, the prices and returns of various assets have also been impacted by geopolitical risk (Bedowska-Sojka et al., 2022; Bossman et al., 2023a, 2023b; Boungou & Yatié, 2022). Common to these works, the impact of geopolitical risk on financial markets is explained by the fact that geopolitical risk is accompanied by high uncertainty and turmoil, which triggers risk transmission and spillover effects (Bossman et al., 2023a, 2023b; Mensi et al., 2023a, 2023b).

Owing to the heterogeneity among various financial assets, two important issues are worth noting. First, in as much as global policy uncertainty is important, the role of regional uncertainty factors in shaping the dynamics of assets

from regional markets cannot be overlooked owing to the degree of financial market integration (Asafo-Adjei et al., 2022b). Second, the impact of policy uncertainty within regional market blocs on various assets from the region needs to be empirically ascertained to influence economic policy design, market regulation, and risk management. Given that the effect of the recent geopolitical risk on the European Union (EU) is relatively stronger (Sun et al., 2022), an empirical analysis of this phenomenon is worth undertaking. Therefore, we analyze three major economic policy uncertainty (EPU) metrics, namely: Global EPU (GEPU), European Union EPU (EEPU), and United States EPU (USEPU). Our goal is to investigate how these EPU metrics affect the EU stocks from different sectors of economic activity. In addition, we ascertain the effect of geopolitical risk and investor sentiment on various EU sectoral stocks.

In this study, we document asymmetric relationships between the fluctuations in various EPU metrics and diverse EU sectoral stocks. The main contribution to the existing body of knowledge is as follows. To the best of our knowledge, the exact impacts of different metrics of economic policy uncertainty, geopolitical risk, and market sentiment on the EU equity sectors have not been adequately documented. This issue has been becoming vitally important due to increasing interdependencies among country-specific and regional economies and capital markets. It is worth noting that the interrelations among the member states of the European Union (EU) are likely to be relatively more intense than within and between other regions around the globe. This relative strength of the financial and economic interdependence of the EU countries has its roots in the existence of numerous EU-wide and bilateral agreements and treaties as well as common market regulations and economic policies. Solid ties among the EU member states are likely to result in high levels of interconnectedness between the respective capital markets, hence, urging a detailed assessment of the EU stocks' performance under the influence of common driving factors, such as EPU, geopolitical risk and market sentiment. Our research responds to this necessity. We investigate how the above-mentioned drivers influence the returns of the EU equities per sector of economic activity under bearish, bullish and normal market conditions. Our research resorts to parametric and nonparametric quantile-based techniques. We provide relevant insights to policy makers, market regulators, and financial market participants, by documenting how economic sectors react to substantial changes in common driving factors at distinct states of the markets.

In summary, our findings are seven-fold. First, we document that various economic policy uncertainty measures have a generally low predictive influence on the EU sectoral stocks across various quantiles. Second, European Union EPU possesses the highest predictive ability on the EU sectoral stock returns. Third, the effects of economic policy uncertainty, geopolitical risk, and market sentiment on the EU sectoral stocks are asymmetric. Fourth, various economic policy uncertainty measures have negative (positive) relationships with EU sectoral stocks across the bearish (bullish) periods of economic activity. Fifth, the downside risk of EU stock returns could hedge against economic policy uncertainty at bearish conditions only. Sixth, the EU stocks could hedge against GPR in stressed market conditions. In addition, seventh, investor sentiment could favorably hedge against the downside risk of the EU sectoral stocks.

The remainder of the study is systematized as follows. Section 2 provides the literature review focused on the strands of research addressing each of the analyzed driving variables. Section 3 presents the data metrics and econometric approaches. Section 4 discusses the empirical findings and Sect. 5 concludes the study.

2 Literature review

In the literature review section, we have three subsections that include each variable separately so that we can understand the different opinions related to the research topic. In other words, each of the three subsections addresses one of the three driving variables, namely, economic policy uncertainty (EPU), geopolitical risk (GPR), and market sentiment (VIX). Such segregation of the literature allows us to provide a more focused discussion of each of the three global driving factors employed in our research.

2.1 Economic policy uncertainty—EPU

As referenced in the previous section, the influence of EPU on asset values might manifest itself along several strands; namely affecting crucial decisions of economic agents such as consumption, saving, investment, and employment; altering financing and production costs, and raising risks in financial markets by casting doubts about government support. Moreover, inflation, interest rates, and estimated risk premiums also depend upon EPU (Gubareva, 2021a; Rebucci et al., 2022). Hence, it is theoretically justified to explore the nexus between EPU and stock market performance, especially so given the recent COVID-19 pandemic setup (Yousaf et al., 2023) and the currently unfolding military conflict between Russia and Ukraine (Bossman & Gubareva, 2023; Bossman et al., 2023a, 2023b). Below, we discuss a set of relevant recent works on this subject matter.

Among recent studies dedicated to the effects of EPU on stock market returns are Kundu and Paul (2022). This paper contributes to the existing bode of knowledge by answering the question of how stock market returns and volatility respond to EPU under bullish and bearish market conditions. The authors use monthly frequency data on G7 countries from 1998 to 2018 and employ the two-regime Markov-switching VAR model for each country and all countries for the two extreme states of the market. Their outcomes indicate that an increase in EPU makes stock returns decay and volatility grow in the immediate future. Interestingly enough, the authors demonstrate that an increase in EPU makes stock returns in future time periods augment because investors start demanding higher uncertainty premiums, which also leads to a decrease in volatility. The results show that the influence of EPU is significant (not significant) in the bear (bull) market. Further, the authors apply the three-regime Markov-switching VAR model for separate countries and the G7 as a whole. Their estimation of the three- regime model corroborates their findings from the two-regime Markov-switching VAR model.

In parallel, Albrecht et al. (2022) investigate EPU and stock markets' co-movements. The authors study the direction of the relationship between EPU and equity markets. They analyze time-variant co-movements between the EPU index and a set of stock market indices, namely, S&P500, UK100, Nikkei225, and DAX30 at different investment horizons. Their investigation indicates that, during financial turbulences on a global scale, the EPU index lags behind the analyzed equity markets at longer horizons, especially in the US, Germany, and Japan. The lag between the movements in the EPU index and the chosen equity market indices is within the 2-to-6-month interval for investment horizons longer than 32 months. Moreover, the authors provide evidence of the existence of the short-run effects of EPU on stock markets.

In what specifically concerns the US geography, Javaheri et al. (2022) explore EPU and the US stock market trading. This research assesses the effects of EPU and economic factors on the stock market indices in the USA using, among other approaches, the quantile-based models. The authors find that declining economic and political uncertainty indicators make the stock market indices increase. In addition, their outcomes imply that the influence of inflation and GDP variables follows nonlinear patterns. In addition, the results based on the quantitative regression techniques demonstrate asymmetric effects of inflation and GDP on stock market transactions.

An interesting study of Germany EPU and its linkage to geopolitical risk in the context of the Russia–Ukraine conflict is performed by Shen and Hong (2023). The authors demonstrate that the still ongoing military hostilities between Russia and Ukraine have increased geopolitical risks and global economic policy uncertainty, causing an increasingly strained international environment. They take Germany as an example to analyze whether the time-varying risks can be transmitted from geopolitical risks to EPU. Their study is based on the time-varying Granger-causality tests. Shen and Hong (2023) conclude that the risk emanating from geopolitical risks and EPU is influenced by the Russia–Ukraine tensions. Moreover, the authors demonstrate that this unidirectional relation possesses asymmetric features. They show that augmented geopolitical risks might amplify Germany's EPU.

The above-discussed paper indicates that the EPU and its influence on stock market performance represent a hot and important research topic. We see, that a set of European countries, such as G7 member-states, receive certain attention from the research community, however, to the best of our knowledge, there is no study dedicated to the EU stock market performance and their dependence on diverse EPU indicators, especially from the perspective of the equity returns, analyzed by sectors of economic activity. Our research bridges this gap.

2.2 Geopolitical risk—GPR

In respect to GPR, as already outlined in the Introduction, a country's and/or region's economic vulnerabilities and grown opportunities in a major part depend on the respective geographic location and proper and neighboring political environment. Moreover, major crises of the current century are geopolitical

in their nature. They have substantially influenced the worldwide stock market performance with their particular impacts differing across countries and geographies. Because the EU is a geographic neighbor of such countries as Russia and Ukraine, which are currently involved in a military conflict, the EU economies and financial markets are relatively vulnerable to conflict-triggered increases in GPR. Hence, it is no surprise that the linkages between GPR and diverse financial markets have been gaining considerable attention in the recent literature (Agyei, 2023; Albaity et al., 2023; Bossman & Gubareva, 2023; Umar et al., 2023b). Below, we provide a discussion of the relevant recent works on this subject.

For instance, Albaity et al. (2023) investigate the heterogeneity of GPR, EPU and sentiment influence on oil and Islamic banking stocks during the COVID-19 pandemic. The authors analyze 137 conventional and Islamic banks in sixteen Middle East and North Africa countries, by means of the unconditional quantile regression technique. The data sample spans from February 2020 to July 2021. Albaity et al. (2023) demonstrate that COVID-19 investor sentiment and EPU negatively influence bank stock returns. However, oil returns are positive and significant only in the first quantile. In its turn, GPR negatively impacts bank returns up to the median quantile, while the impact is positive in the upper quantiles. Moreover, the authors show that Islamic banks outperformed conventional banks in all quantiles. In addition, it is found that GPR negatively influences the Islamic bank returns up to the 75th quantile. This research provides important insights into the heterogeneity of market conditions and dependencies of Islamic bank stocks on GPR, EPU, and market sentiment, which are the global drivers that among others should be considered when implementing investment decisions and policies.

In their turn, Bossman and Gubareva (2023) investigate the asymmetric impacts of GPR on stock markets in E7 and G7 countries during the Russia–Ukraine conflict. The authors employ the quantile-on-quantile regression is employed to study the behavior of the E7 and G7 stocks and find that GPR influences equity markets in a market-specific and, also, asymmetric manner. In particular, they find that among the G7 stocks, the only European equity market resilient to GPR is France, along with Japan and the US equities. The authors duly highlight the portfolio and policy implications of their results.

In parallel, Bossman et al. (2023a) investigate the performance of the EU sectoral stocks amid geopolitical risk, market sentiment, and crude oil implied volatility during the period of the Russia–Ukraine tensions. Their work examines the asymmetric relationships between the EU stocks per sector of economic activity and GPR, oil, oil implied volatility, and market sentiment during turbulent times of geopolitical unrest. Employing both, parametric and nonparametric quantile techniques, the authors use daily frequency data on eleven sectors in addition to crude oil prices and three sentiment-driven indices, namely GPR, the crude oil volatility (OVX), and investor sentiment (VIX) over the period between January 2020 and October 2022. Their findings from the causality-in-quantile-means test indicate that the EU stock returns from different sectors are asymmetrically predicted by WTI, OVX, VIX, and GPR. The results from the quantile regression and quantile-on-quantile regression metrics demonstrate, among others, that in bearish periods, the EU stocks could

hedge against GPR. Their outcomes provide relevant insights for portfolio managers and market regulators.

Zhang et al. (2023) investigate the linkages between GPR and stock market volatility from a global perspective. This study uses dynamic panel data from thirty-two countries, including several EU countries and resorts to the bias-corrected least-squares dummy variable estimator. The results show that GPR has a significant positive effect on stock market volatility, which is not affected by control variables. In addition, the authors conclude that the GPR impact on stock market volatility is more significant for emerging economies, crude oil exporters, and countries at peace. Their research offers new evidence for the linkage between GPR and stock market volatility.

As we see from the papers addressed above, GPR and its influence on stock market performance are relevant and contemporaneous research subjects. We see, that the nexus between GPR and EU stocks have already received certain attention from scholars and researchers. However, further and deeper research into this subject matter is highly desirable. Our work helps to advance the knowledge frontiers in this domain.

2.3 Market sentiment—VIX

In what concerns market sentiment, we gauge it by employing the CBOE Volatility Index, or VIX. It projects the probable range of immediate future alterations in the US stock markets. VIX reaches its highest levels when the equity market is most unsettled. Therefore, academic scholars and market participants tend to refer to VIX as a fear gauge. Considered from this point of view, VIX is but a measure of global market sentiment. It is worth noting that several studies have investigated the causal influence of VIX on European stocks' behavior (Agyei & Bossman, 2023; Bossman et al., 2023a; Li et al, 2020; Magner et al., 2021).

For instance, Magner et al. (2021) investigate the predictive power of stock markets' expectations volatility. The authors employ implied volatility indices as a tool for estimating changes in the synchronization of stock markets. In particular, they assess the predictive power of implied stock market volatility indices on synchronizing global equity indices returns. The authors design the correlation network of twenty-six stock indices and implement in-sample and out-of-sample tests to assess the predictive power of VIX, VSTOXX, and VXJ implied volatility indices. To measure markets' synchronization, they use the Minimum Spanning Tree length and the length of the Planar Maximally Filtered Graph. Their results demonstrate a high predictive power of all the volatility indices, both individually and jointly, though the VIX predominates over the analyzed indicators. The authors conclude that an increase in the markets' volatility expectations, captured by the implied volatility indices, is a good Granger predictor of an increase in the synchronization of returns in the following month. Hence, they argue that estimating, monitoring, and predicting returns' synchronization is essential for investment decision-making, especially for diversification strategies and regulating financial systems.

Agyei and Bossman (2023), in their turn, explore the nexus between investor sentiment and Greece, Ireland, Italy, Portugal, and Spain (GIIPS) stock market returns. Their study analyzes the conditional and unconditional co-movements of stock market returns of GIIPS economies incorporating investor fear in their time–frequency connectedness. The authors resort to the bi-, partial, and multiple wavelet approaches. Their results explain that the high interdependencies between the stock market returns of GIIPS across all time scales are partly driven by investor fear, implying that extreme investor sentiment could influence stock market prices in GIIPS. The lagging role of Spanish stock market returns manifests at zero lags at high (lower) and medium frequencies (scales). At lower frequencies (higher scales), particularly quarterly-to-biannual and biannual-to-annual, Spanish and Irish stock markets, respectively, lag all other markets. The authors conclude that in spite of minimal portfolio diversification and safe-haven benefits, obtainable with the GIIPS stocks, their volatilities could be hedged against by investing in the US VIX. Therefore, their results provide important implications for international portfolio design and risk management.

Mensi et al. (2023b) study spillovers and connectedness among G7 real estate investment trusts, focusing on the effects of investor sentiment and global factors. The authors employ the TVP-VAR methodology to investigate dynamic spillovers. They study the impacts of sentiment, geographical risk, policy uncertainty, US Treasury rate, and volatility on the intensity of the spillovers and find that their effects across quantiles are non-linear and non-monotonic. In particular, the authors assess the influence of VIX on the dependent variable, which is spillover magnitude. The study is performed separately for the entire sample, the pre-COVID-19, and COVID-19 periods. However, differently from other driving factors, the authors find that investor sentiment impact grows monotonically from near zero negative values for the lower quantiles to positive figures for the upper quantiles. Nonetheless, in general terms, the authors conclude that the lower and upper quantiles of returns are more susceptible to changes in driving factors, including VIX than those quantiles in the middle.

Najaf et al. (2023) investigate the nexus between the build-up of the Russia–Ukraine conflict and stock returns, providing evidence from the Russian and Ukrainian stock markets. With the sake to analyze the impact of the conflict-related news on stock returns, the authors employ data for the United States, Russian and Ukraine stock indices, oil price and VIX. They control the oil price, US stock returns, Chicago Board VIX, and the difference in stock returns from Russia and Ukraine. This study presents the two main results. First, the conflict-related news between the two countries enhances volatility and causes a significant decline in the stock market indices for both countries. Second, the Russian stock market faces a steeper decline in the build-up and the actual beginning of the military operation than the Ukrainian stock market. The authors explain this finding by arguing that the Russian markets fear the adverse economic consequences that stem from the sanctions the US and the Western world keep imposing against Russia. The study concludes that global portfolio investors should stay away from the stock markets of the countries involved in military conflicts, in particular, and away from equity markets, in general, looking instead for safe-haven assets.

The above-discussed paper indicates that the VIX and its influence on stock market performance represent a hot and important research topic. We see, that a set of European countries, such as G7 member-states and GIIPS economies, receive certain attention from the research community, however, to the best of our knowledge, there is no study dedicated to the EU stock market performance and their dependence on diverse VIX, especially from the perspective of the equity returns, analyzed by sector of economic activity. Our research fills in this void.

3 Data and methods

3.1 Data

We use monthly data on eleven EU sectors (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities), the Chicago Board Options Exchange market sentiment (VIX) index, and the geopolitical risk (GPR)[1] index developed by Caldara and Iacoviello (2022). All data cover the period from February 2013 to September 2022. The choice of our dataset is justified by the possibility to incorporate into the study several time intervals subjacent to important events and specific market conditions of global and EU importance. Namely, these situations encompass the oil collapse in 2014, quantitative easing and low interest rate environment, Brexit, the China–US trade war, the COVID-19 pandemic, and the ongoing Russia–Ukraine military hostilities. Following Bossman et al. (2023a, 2023b, 2023c) and Khan et al. (2022), the natural logarithm transformation of the GPR and all EPU series (GEPU, EEPU, and USEPU) is utilized to ensure the stability of the series. For all other data, returns are used. Except for the GPR data constructed by Caldara and Iacoviello (2022), all data were gleaned from Bloomberg. We construct our sample to cover the EU stocks performance throughout the 2014–2016 oil price plunge uncertainty, the Brexit vote in 2016 and the 2018–2019 US–China trade wars as well as the recent two major events of a global reach; namely, the COVID-19 pandemic, which has experienced its peak in March 2020 (Gubareva, 2021a), and the factual invasion of Ukraine by Russia on February 24, 2022 (Bossman et al., 2023a, 2023b, 2023c). In particular, these two recent events present a unique scenario to observe the behavior of various sectoral stocks from the EU in extreme policy uncertainty, market sentiment, and geopolitical risk conditions.

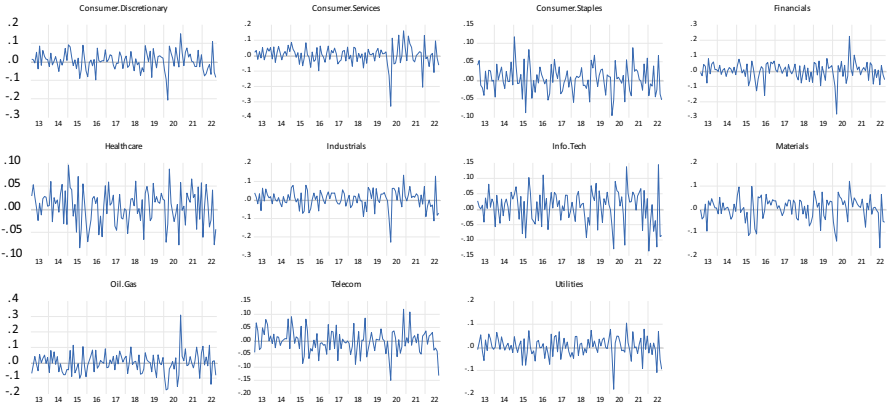
The sample statistics (Table 1) show that, over the sample period, among the considered EU sectors, the mean stock returns are negative for financials, oil and gas, and telecom but positive for consumer discretionary, consumer staples, consumer services, healthcare, industrials, information technology, materials, and utilities. The return series for consumer services, financials, and industrials are leptokurtic. The series for consumer staples and oil and gas sectors are positively skewed while all other sectoral series are negatively skewed. Among the logarithmic forms of

[1] Data downloaded from https://www.matteoiacoviello.com/gpr.htm on November 02, 2022.

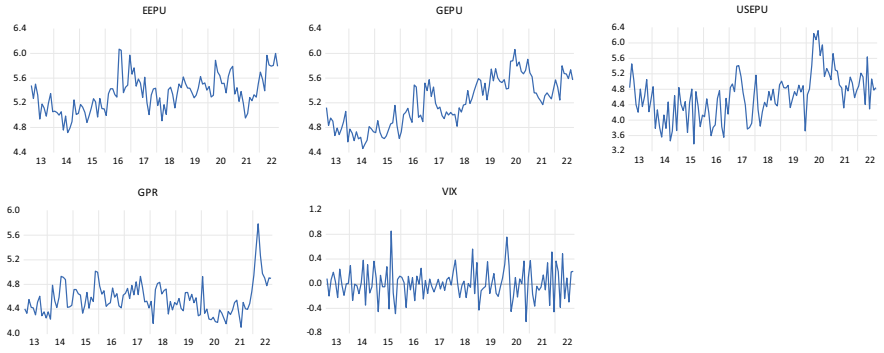
Table 1 Sample statistics

	Mean	Min	Max	Range	Median	Std. dev	Skewness	Kurtosis	Normtest.W	ADF.stat	PP.stat	Obs
Panel A: sectoral stocks												
C. Disc	0.0035	−0.2073	0.1518	0.3591	0.0057	0.0516	−0.3837	1.5603	0.9788*	−10.3961***	−10.3944***	116
C. Serv	0.0026	−0.3282	0.1612	0.4894	0.0098	0.0622	−1.3521	6.5527	0.9029***	−11.8801***	−11.8225***	116
C. Staples	0.0035	−0.0957	0.1174	0.2131	0.0031	0.0364	0.0792	0.3098	0.9943	−11.5268***	−12.0760***	116
Financials	−0.0002	−0.2795	0.2248	0.5043	0.0076	0.0585	−0.7772	4.8414	0.9203***	−11.2212***	−11.2220***	116
Healthcare	0.0051	−0.0837	0.0954	0.1791	0.0112	0.0379	−0.2409	−0.4426	0.9853	−11.3251***	−11.3273***	116
Industrials	0.0041	−0.2284	0.1340	0.3625	0.0067	0.0503	−0.8805	3.0747	0.9505***	−11.0560***	−11.0642***	116
Info. Tech	0.0070	−0.1356	0.1441	0.2797	0.0149	0.0539	−0.3593	0.1278	0.9774**	−11.8058***	−11.7940***	116
Materials	0.0020	−0.1672	0.1204	0.2877	0.0087	0.0504	−0.7091	0.6960	0.9658***	−9.8303***	−9.7926***	116
Oil and gas	−0.0025	−0.1761	0.3095	0.4856	−0.0031	0.0674	0.5512	2.9696	0.9581***	−11.0278***	−11.0242***	116
Telecom	−0.0018	−0.1499	0.1194	0.2693	−0.0005	0.0456	−0.1265	0.7205	0.9883	−11.1643***	−11.1659***	116
Utilities	0.0025	−0.1812	0.1049	0.2861	0.0014	0.0437	−0.7294	1.8212	0.9671***	−12.3005***	−12.6393***	116
Panel B: market sentiment, geopolitical risk, and economic policy uncertainty indices												
VIX	0.0069	−0.6143	0.8526	1.4669	−0.0026	0.2565	0.3780	0.5810	0.9840	−15.0257***	−26.9126***	116
GPR	4.5674	4.1056	5.7847	1.6791	4.5242	0.2613	1.2749	3.3476	0.9260***	−4.7374***	−4.6885***	116
GEPU	5.1894	4.4578	6.0644	1.6066	5.1724	0.3863	0.0878	−1.0716	0.9704**	−1.8854	−2.3005	116
EEPU	5.3471	4.7167	6.0714	1.3547	5.3358	0.2879	0.2947	−0.2038	0.9848	−4.3616***	−4.4563***	116
USEPU	4.6210	3.3783	6.3229	2.9446	4.6483	0.5951	0.2614	0.1457	0.9797*	−3.6929***	−5.3621***	116

Notes: This table displays the sample statistics and results from normality and stationarity tests. The sample includes eleven EU sectoral monthly stock market returns (consumer discretionary (C. Disc), consumer services (C. Serv.), consumer staples (C. Staples), financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities) and investor sentiment (VIX) in addition to the natural logarithm transformation of geopolitical risk (GPR), global economic policy uncertainty (GEPU), EU economic policy uncertainty (EEPU), and economic policy uncertainty of the US (USEPU). The summary statistics include the number of observations (Obs.), the minimum and maximum observations, the mean, median, standard deviation (Std. Dev.), skewness, and kurtosis. The Jarque–Bera statistics for the normality test (Normtest.W) and the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) stationarity tests statistics are also reported with 1% (***), 5% (**) and 10% (*) as accompanying probabilities



Panel A: EU sectoral stock returns.



Panel B: Uncertainties, GPR, and sentiment.

Fig. 1 Time series plots. Notes: This figure shows the plots of monthly return series for eleven EU sectoral stocks (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities) and investor sentiment (VIX) in addition to the natural logarithm transformation of geopolitical risk (GPR), global economic policy uncertainty (GEPU), EU economic policy uncertainty (EEPU), and economic policy uncertainty of the US (USEPU). The sample period covers February 2013 to September 2022. The vertical axis of each plot displays the return or natural log transformation while the horizontal axis keeps track of calendar time (in years). Source: Bloomberg, except for GPR extracted from https://www.matteoiacoviello.com/gpr.htm

the geopolitical risk (GPR) index and economic policy uncertainty indices (GEPU, EEPU, and USEPU), GPR records its mean at 4.57, peaking at a 5.78 high. EEPU records the highest mean of 5.35 among the EPU indices while the series with the highest peak is the USEPU, at 6.32. Together with consumer staples, healthcare, and telecom, the series for VIX and EEPU fail to reject the normality hypothesis while all other series reject the normality hypothesis. In terms of stationarity, all series—except GEPU—were stationary, allowing us to use both parametric and nonparametric quantile-based metrics.

Interesting trajectories of the analyzed series are shown in Fig. 1. Notably, all sectoral stocks recorded a sharp drop in returns in 2020, which marks the COVID-19 era.

It was within that period that GEPU and USEPU recorded their peaks. For EEPU, its peak is found in 2016, which could be traced to Britain's exit decision in 2016 (Bossman et al., 2022d; Kadiric & Korus, 2019). Another comparable peak of the EEPU is found in 2022, which corresponds to Russia's invasion of Ukraine, which started in late February 2022. This explains the fact that the peak in GPR is also spotted in 2022. It is important to reiterate that these events provide an opportunity for us to document the asymmetric effects of various policy uncertainty measures, geopolitical risk, and investor sentiment on the EU sectors of economic activity.

3.2 Methods

Our methodological approach involves two steps. To ascertain whether various EPU measures and VIX have a predictive influence on EU sectoral stock returns across various quantiles, we employ the causality-in-quantile test developed by Jeong et al. (2012). The asymmetric relationships between the variables across the bullish, bearish, and normal conditions of economic activity are tested using the parametric quantile regression (QR) and the nonparametric quantile-on-quantile regression (QQR) approaches. Here, we reiterate that the chosen sample allows us to incorporate into the study several time intervals subjacent to important events and specific market conditions—such as the oil collapse in 2014, quantitative easing and low interest rate environment, Brexit, the China–US trade war, the COVID-19 pandemic, and the ongoing Russia–Ukraine geopolitical tensions—of global and EU importance. In the face of these events and with data sample spanning from 2013 to 2022, it is important to note that markets evolve through bearish, bullish, and normal conditions, necessitating that the responsiveness of EU stocks belonging to various sectors of economic activity is envisaged from not only the median (normal) condition but also from the bearish and bullish states of the market. This partly informs our choice of both parametric (i.e., the classical quantile regression) and nonparametric (causality-in-quantile-means and QQR) quantile-based econometric techniques. The steps involved in the causality-in-quantile means test and the QQR regression approach are described below.

3.2.1 Causality-in-quantiles

The predictive power of EEPU, GEPU, USEPU, GPR, and VIX for returns of any EU sectoral stock across various quantiles of the EU sectoral stock returns is examined through the causality-in-quantiles test proposed by Jeong et al. (2012) in the following steps:

If y_t is the stock returns from any EU sector and x_t is any of EEPU, GEPU, USEPU, GPR, and VIX, we can evaluate the hypothesis that, in the θth quantile, if $\{y_{t-1}, \ldots, y_{t-p}, x_{t-1}, \ldots, x_{t-p}\}$ is the lag vector, x_t possesses no causal influence on y_t, given that:

$$Q_\theta\left(y_t|y_{t-1}, \ldots, y_{t-p}, x_{t-1}, \ldots, x_{t-p}\right) = Q_\theta\left(y_t|y_{t-1}, \ldots, y_{t-p}\right). \tag{1}$$

In the θth quantile, if we have $\{y_{t-1}, \ldots, y_{t-p}, x_{t-1}, \ldots, x_{t-p}\}$ as the lag vector, x_t has a causal influence on y_t when:

$$Q_\theta\left(y_t|y_{t-1},\ldots,y_{t-p},x_{t-1},\ldots,x_{t-p}\right) \neq Q_\theta\left(y_t|y_{t-1},\ldots,y_{t-p}\right). \tag{2}$$

Here, the θth quantile of y_t is $Q_\theta(y_t|\bullet)$. t predicts the conditioned quantiles, $Q_\theta(y_t|\bullet)$, of y_t such that the quantiles fall within the range$0 < \theta < 1$.

Further, when $Z_t = Y_t, X_t$ are accompanied by vectors $y_{t-1} = y_{t-1},\ldots,y_{t-p}$ and $x_{t-1} = x_{t-1},\ldots,x_{t-p}$, their conditioned distribution functions may be expressed as $F_{y_t|Z_{t-1}}(y_t|Z_{t-1})$ and $F_{y_t|Y_{t-1}}(y_t|Y_{t-1})$, respectively, given Z_{t-1} and Y_{t-1} as conditioned vectors. $F_{y_t|Z_{t-1}}(y_t|Z_{t-1})$ is assumed to be strictly continuous in y_t for practically all Z_{t-1}.

So, if $Q_\theta\left(Z_{t-1}\right) \equiv Q_\theta(y_t|Z_{t-1})$ and $Q_\theta\left(Y_{t-1}\right) \equiv Q_\theta(y_t|Y_{t-1})$, we arrive at $F_{y_t|Z_{t-1}}\{Q_\theta\left(Y_{t-1}\right)|Z_{t-1}\} = \theta$, with the probability $P = 1$.

From Eqs. (1) and (2), the hypothesis for each causality-in-quantile test may be noted as:

$$H_0 : P\left\{F_{y_t|Z_{t-1}}\left\{Q_\theta\left(Y_{t-1}\right)|Z_{t-1}\right\} = \theta\right\} = 1. \tag{3}$$

$$H_1 : P\left\{F_{y_t|Z_{t-1}}\left\{Q_\theta\left(Y_{t-1}\right)|Z_{t-1}\right\} = \theta\right\} < 1. \tag{4}$$

3.2.2 Quantile-on-quantile regression

Sim and Zhou's (2015) QQR model is designed in a manner that combines nonparametric steps with Koenker and Bassett's (1978) quantile regression (QR) metric, which is a straightforward extension of the traditional linear regression model that quantifies the relationship between the regressor and the conditional distributions of the regressand. Therefore, by its feature, the QQR metric helps to assess, in totality, the relationship between the regressor and the regressand across the distributions of both the regressand and regressor, providing a comprehensive view of the connections between the variables (Asafo-Adjei et al., 2022a; Bossman et al., 2022e).

In any market event within the evolvement of financial markets, diverse bearish, bullish, and normal conditions may be observed at different conditions of EPUs, GPR, and VIX. Therefore, rather than using classical metrics like linear regression and QR, an amalgamation of the two models will render a wide-ranging understanding of the fundamental interrelations between EPUs, GPR, and VIX, and the EU sectoral stocks. In this study, we apply the nonparametric QQR metric to model the effect of various EEPU, GEPU, USEPU, GPR, and VIX quantiles on different return distributions of the EU sectoral stocks.

The QQR model is formularized as:

$$Y_t = \beta^\theta(X_t) + u_t^\theta. \tag{5}$$

Here, Y_t denotes the return on a given EU sectoral stock; X_t is any of EEPU, GEPU, USEPU, GPR, and VIX at day t; $\beta^\theta(\bullet)$ is an unknown parameter determined

as the estimated slope coefficient between the observed values of Y_t and X_t; θ is the θth quantile of the conditional return distribution of a given EU sectoral stock, and u_t^{θ} is the quantile residue with a zero θth quantile.

In what concerns the bandwidth (h) in a nonparametric QQR metric, the correct specification is essential. A wider (narrower) bandwidth comes with a larger bias (variance) for an estimate. To balance the variance and bias, we stick to Sim and Zhou's (2015) recommendation of $h = 0.05$.

4 Empirical results

This section presents and discusses the empirical results from our analysis in three steps. First, the causal influence of each of EEPU, GEPU, USEPU, GPR, and VIX on various EU sectoral stock returns is ascertained based on the quantile-causality-in-means test. Second, facilitated by a parametric approach, we analyze the QR results, detailing the effect of each of EEPU, GEPU, USEPU, GPR, and VIX on various EU sectoral stock return distributions. Third, through the nonparametric QQR approach, we analyze how various quantiles of each of EEPU, GEPU, USEPU, GPR, and VIX affect various EU sectoral stock return distributions.

4.1 Quantile causality-in-means analysis

In this sub-section, we present the causal influence of EEPU, GEPU, USEPU, GPR, and VIX on various distributions of the EU stock returns based on the quantile-causality-in-means test. This approach could be used to test the predictive ability of an independent on a dependent variable in terms of quantile mean and variance. However, in this analysis, we resort to the quantile mean only, as applied in existing works (e.g., Agyei, 2022; Alsubaie et al., 2022; Bossman et al., 2022c; Umar et al., 2023a). The outcomes from the causality-in-quantile-means analysis are pictorially (numerically) presented in Figs. 2, 3, 4, 5 and 6 (Tables 2, 3, 4, 5, 6), for EEPU, GEPU, USEPU, GPR, and VIX, respectively. For every plot in each figure, the thick horizontal line shows the critical value (CV) at a 95% confidence interval, i.e., a 5% significance level. In each case, the predictor variable is named first, followed by the response variable, which includes the EU sectoral stock returns.

The tested hypothesis reads that changes in a given EU sectoral stock return are Granger-caused by changes in a named predictor variable. A rejection of the tested hypothesis at 1% (CV = 2.567), 5% (CV = 1.96), and 10% (CV = 1.645), means that variations in a named sectoral stock are Granger-caused by changes in the predictor variable. Taking into consideration the above guide, and with reference to both the graphical (Figs. 2, 3, 4, 5, 6) and numerical (Tables 2, 3, 4, 5, 6) test statistics, we can ascertain whether any of EEPU, GEPU, USEPU, GPR, and VIX significantly predicts the returns for any EU sectoral stock.

The results show that the null hypothesis is maintained across several quantiles for most pairs. Yet, there are some interesting observations to be mentioned. First, in terms of GEPU (Fig. 2; Table 2), the hypothesis is rejected for

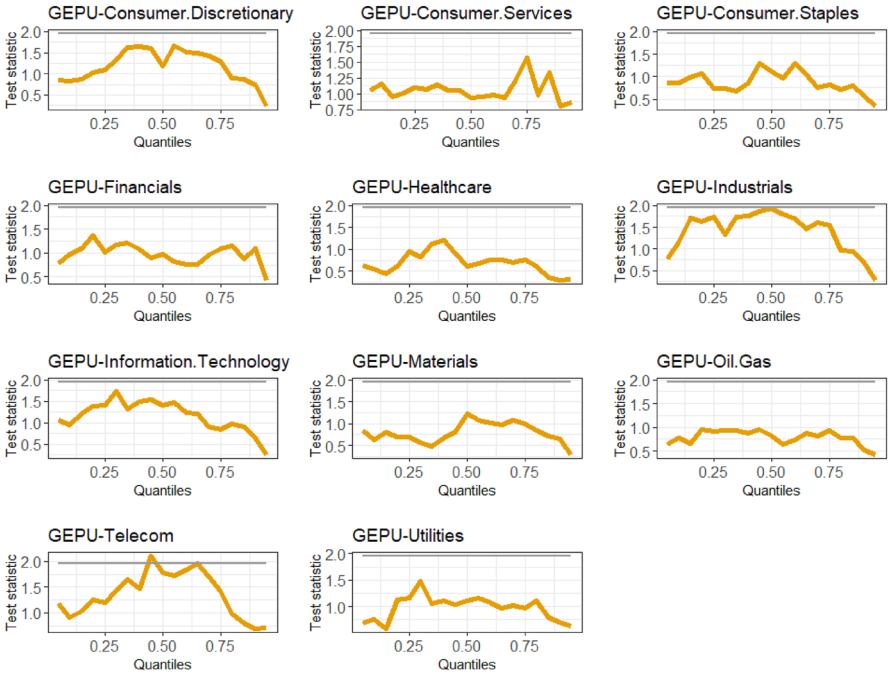


Fig. 2 Causality analysis: GEPU and EU sectoral stocks. Notes: This figure shows the plots of test statistics from the causality-in-quantile means on the predictive power of changes in GEPU on changes in the returns of EU sectoral stocks. The vertical axis of each plot measures the test statistics while the horizontal axis keeps track of the quantiles of stock returns

the industrials and telecom sectors. Thus, the stock returns from these sectors in the EU are significantly predicted by global economic policy uncertainty across the quantile range of 0.35–0.60. Second, for EEPU (Fig. 3; Table 3), we find a significant predictive power for it vis-à-vis the stock returns from consumer discretionary (across the quantile range 0.20–0.35), consumer services (across the quantile range 0.40–0.50), industrials (across the quantile range 0.15–0.60), and information technology (across the quantile range 0.40–0.50). Third, in terms of USEPU (Fig. 4; Table 4), the hypothesis is maintained for all sectors. Fourth, for GPR (Fig. 5; Table 5), the hypothesis is rejected for consumer discretionary (across the quantile range 0.40–0.55) and IT (across the quantile range 0.25–0.45). Lastly, in terms of VIX (Fig. 6; Table 6), the hypothesis is rejected for information technology (across the quantile range 0.35–0.65) and materials (across the quantile range 0.60–0.65).

Therefore, among the various EPUs, the EEPU has the highest predictive power while the USEPU has no predictive power on stock returns from the EU. To learn more about the connection between these variables, we delve into their asymmetric relationships using the QR and QQR techniques in the subsequent sub-sections.

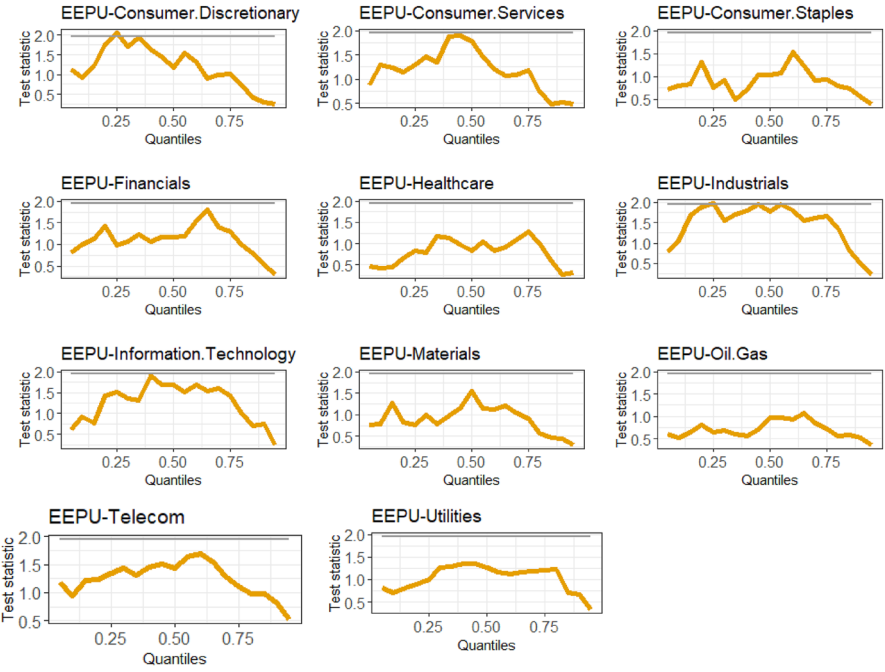


Fig. 3 Causality analysis: EEPU and EU sectoral stocks. Notes: This figure shows the plots of test statistics from the causality-in-quantile means on the predictive power of changes in EEPU on changes in the returns of EU sectoral stocks. The vertical axis of each plot measures the test statistics while the horizontal axis keeps track of the quantiles of stock returns

4.2 Quantile regression (QR) analysis

In this sub-section, we present the relationship between each predictor variable (i.e., GEPU, EEPU, USEPU, GPR, and VIX) and various distributions of the EU sectoral stock returns via the parametric QR metric. The outcomes from the QR analysis are numerically presented in Tables 7, 8, 9, 10 and 11, for GEPU, EEPU, USEPU, GPR, and VIX, respectively.

The results on the effects of the various EPUs, as presented in Tables 7, 8 and 9, share a similar pattern. We observe three important features. The first is that GEPU, EEPU, and USEPU have significant negative effects on stock returns from various EU sectors across the lower quantiles, specifically across the quantile range of 0.05–0.35. The fact that these negative effects are spotted across the bearish markets suggests that stock returns from the EU, without discriminating among the sectors, have a negative relationship with economic policy uncertainty, be it either GEPIU, EEPU, or USEPU. Second, at normal trading conditions, which correspond to the median quantiles (0.40–0.50), several mixed (positive and negative) relationships lack statistical significance. Third, across the bullish market conditions, i.e., for the quantile range 0.55–0.95, consistent positive relationships are found between various EPUs and EU sectoral stocks. This means that EU stocks lose their hedge ability against various EPUs during bullish periods.

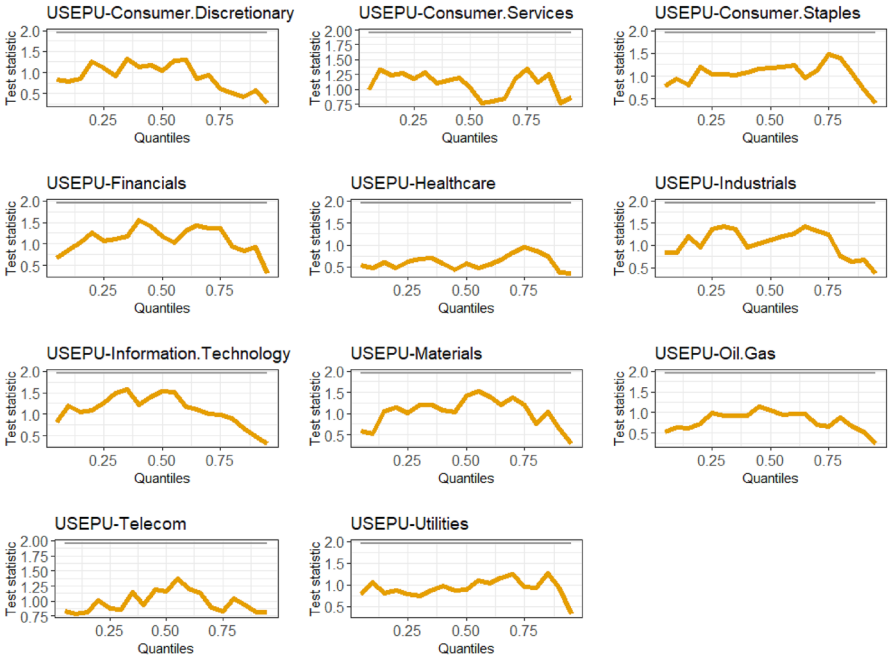


Fig. 4 Causality analysis: USEPU and EU sectoral stocks. Notes: This figure shows the plots of test statistics from the causality-in-quantile means on the predictive power of changes in USEPU on changes in the returns of EU sectoral stocks. The vertical axis of each plot measures the test statistics while the horizontal axis keeps track of the quantiles of stock returns

Thus, the empirical findings from the QR analysis—between EPUs and EU sectoral stocks—suggest that the analyzed sectors of EU stocks could hedge against the downside risk of economic policy uncertainty across extreme periods that resemble bearish market conditions for various sectoral stocks. On the contrary, at bullish conditions of economic activity, EU stocks fail to serve as a hedge against all forms of economic policy uncertainty. It is worth noting that these characteristics of EU stocks vis-à-vis various EPUs are similar to their characteristics against geopolitical risk (GPR), as reported in Table 10. Thus, similar to what is found for the EU stocks' relationships with various EPUs, the results from Table 10 indicate that the relationships between GPR and the considered EU sectoral stocks are significantly negative, insignificant, and significantly positive across the bearish (0.05–0.35), normal (0.40–0.50), and bullish (0.55–0.95) conditions of economic activity, respectively. These findings regarding the GPR influence on various sectoral stocks are consistent with Bossman et al. (2023a, 2023b, 2023c), Bedowska-Sojka et al. (2022), and Umar et al. (2022a, 2022b), who underscore mixed impacts of GPR on various financial assets.

In terms of investor sentiment (VIX), as reported in Table 11, the results show a consistent negative relationship between VIX and the EU sectoral stocks across all quantiles. The negative relationships communicate potential hedging attributes of VIX against the EU stocks. Thus, as equity investors hedge against the downside

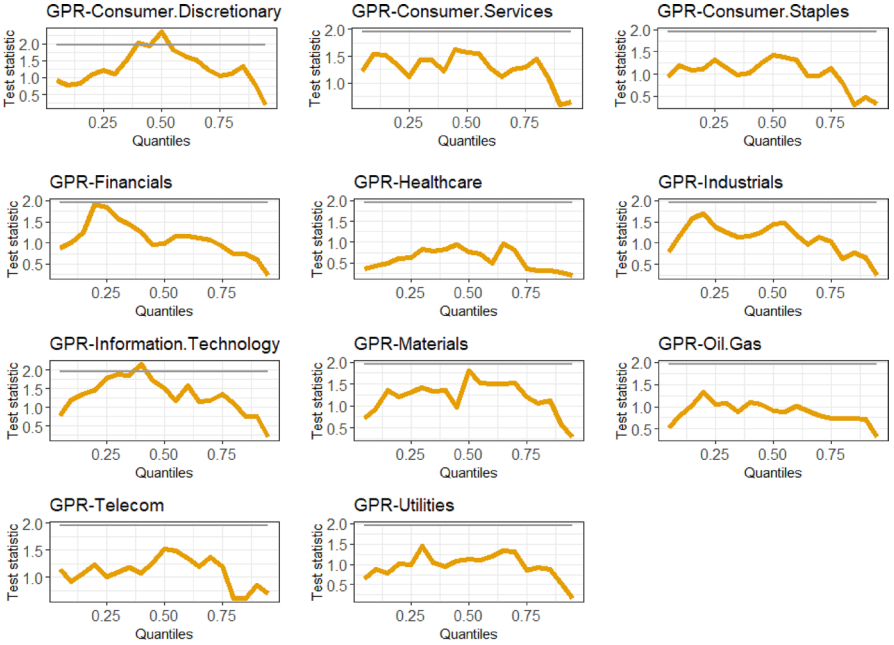


Fig. 5 Causality analysis: GPR and EU sectoral stocks. Notes: This figure shows the plots of test statistics from the causality-in-quantile means on the predictive power of changes in GPR on changes in the returns of EU sectoral stocks. The vertical axis of each plot measures the test statistics while the horizontal axis keeps track of the quantiles of stock returns

risk associated with financial markets, as quantified by the CBOE VIX, they may achieve a shield against shocks from various EU sectors. And all the way around, investments in the VIX, which cater for changes in financial markets, provide a possibility of hedging against shocks from the EU sectoral stocks. This observation is consistent with the existing literature that finds the VIX as a hedging instrument (Asafo-Adjei et al., 2022b; Owusu Junior et al., 2021).

4.3 Quantile-on-quantile regression analysis

In this sub-section, we analyze the relationship between each predictor variable (i.e., GEPU, EEPU, USEPU, GPR, and VIX) and EU sectoral stock returns via the nonparametric QQR method. This analysis is distinct from the QR analysis because, while in the QR analysis, we gauge the effect of the predictor variable on the distributions of the independent variable (i.e., a named EU sector), in the QQR approach, we envisage this relationship by considering how various quantiles of the predictor variable relate to the various distributions of the predicted variable. The real market conditions witnessed by any of the predictor variables, at any point in time, may be different from the conditions in various sectors of economic activity. Hence, to explore the overall relationships between these

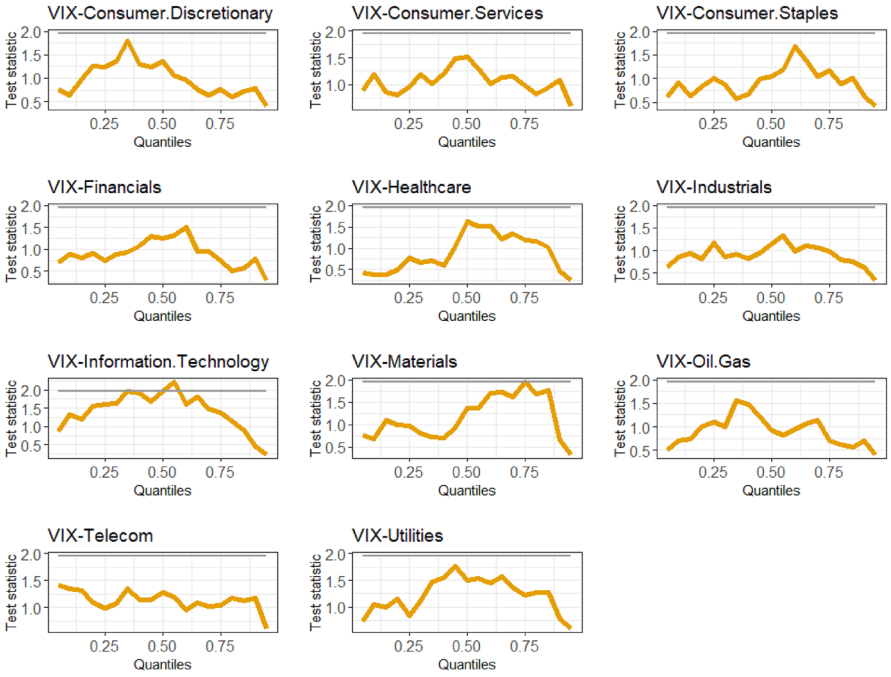


Fig. 6 Causality analysis: GPR and EU sectoral stocks. Notes: This figure shows the plots of test statistics from the causality-in-quantile means on the predictive power of changes in GPR on changes in the returns of EU sectoral stocks. The vertical axis of each plot measures the test statistics while the horizontal axis keeps track of the quantiles of stock returns

variables, across the bullish, normal, and bearish conditions of all variables, the application of the QQR approach is appropriate. Following the conventional practice, the outcomes from the nonparametric QQR analysis are presented in Figs. 7, 8, 9, 10 and 11, for GEPU, EEPU, USEPU, GPR, and VIX, respectively.

In terms of economic policy uncertainty and EU sectoral stocks, Figs. 7, 8 and 9 share some similarities, as the QR results demonstrated. Here, in the QQR analysis, the results demonstrate a mix of positive and negative effects of various EPUs (GEPU, EEPU, and USEPU) on stock returns from EU economic sectors. The findings highlight the fact that the relationships between the variables are asymmetric, demonstrating the relevance of the econometric approaches utilized in this study. Notably, from the various three-dimensional plots, we see that, across the median quantiles of both EU sectoral stock returns and any of the EPUs, the relationships are mainly negative while across the extremes, they are positive. Therefore, we may infer that, in normal market conditions, diversification may be fairly consistent whereas, in bullish and bearish states, hedging against various EPUs with the EU stocks may not be inconsistent. A similar conclusion may apply in the case of geopolitical risk (GPR), as in Fig. 10, but the following peculiar observation is worth noting. For GPR, the EU stocks from

Table 2 Causality-in-means analysis: GEPU and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	0.8525	1.0565	0.8547	0.7812	0.6365	0.7672	1.0617	0.8546	0.6379	1.1801	0.6876
0.10	0.8388	1.1533	0.8574	0.9803	0.5426	1.1400	0.9612	0.6364	0.7713	0.9125	0.7571
0.15	0.8833	0.9537	0.9769	1.0852	0.4398	1.7137*	1.2189	0.7921	0.6673	1.0377	0.5743
0.20	1.0336	1.0117	1.0718	1.3689	0.6144	1.6195	1.3988	0.7024	0.9450	1.2477	1.1320
0.25	1.0980	1.1043	0.7492	1.0163	0.9527	1.7324*	1.4123	0.7028	0.9221	1.2074	1.1671
0.30	1.3343	1.0663	0.7435	1.1647	0.8335	1.3328	1.7410*	0.5780	0.9270	1.4411	1.4852
0.35	1.6138	1.1409	0.6711	1.2150	1.1275	1.7371*	1.3297	0.4865	0.9244	1.6576**	1.0629
0.40	1.6400	1.0590	0.8620	1.0721	1.1999	1.7591*	1.4959	0.6696	0.8673	1.4710	1.1151
0.45	1.5916	1.0580	1.3022	0.8986	0.9007	1.8652*	1.5309	0.8046	0.9587	2.1151**	1.0432
0.50	1.1844	0.9333	1.1078	0.9697	0.6090	1.9236*	1.4116	1.2312	0.8228	1.7879*	1.1053
0.55	1.6764*	0.9604	0.9738	0.8181	0.6679	1.7953*	1.4750	1.0865	0.6371	1.7237*	1.1621
0.60	1.5148	0.9832	1.2923	0.7561	0.7598	1.6867*	1.2306	1.0181	0.7304	1.8354*	1.0715
0.65	1.4789	0.9423	1.0537	0.7629	0.7577	1.4643	1.2205	0.9653	0.8743	1.9588*	0.9675
0.70	1.4155	1.2160	0.7594	0.9486	0.6864	1.6155	0.9118	1.0896	0.8260	1.7169	1.0188
0.75	1.2965	1.5733	0.8211	1.0947	0.7592	1.5503	0.8459	0.9840	0.9338	1.4200	0.9690
0.80	0.8857	0.9816	0.7241	1.1424	0.6162	0.9655	0.9796	0.8467	0.7759	0.9892	1.1163
0.85	0.8834	1.3343	0.8000	0.8747	0.3667	0.9373	0.9201	0.7100	0.7866	0.7995	0.7921
0.90	0.7314	0.8027	0.5727	1.1005	0.2855	0.6824	0.6584	0.6605	0.5196	0.6847	0.7121
0.95	0.2269	0.8635	0.3422	0.4225	0.3179	0.2692	0.2530	0.2845	0.4177	0.7060	0.6400

Notes: This table presents the numerical test statistics from the causality-in-quantile means on the predictive power of changes in global economic policy uncertainty (GEPU) on changes in the returns of EU sectoral stocks. The quantiles are captured under the heading: tau. The statistical significance levels of [5%] and [10%] for the respective critical values 1.96, and 1.645 are represented by **, and *, respectively for the various test statistics

Table 3 Causality-in-means analysis: EEPU and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	1.1341	0.8860	0.7172	0.8075	0.4664	0.8000	0.6134	0.7585	0.6025	1.1751	0.8075
0.10	0.9134	1.3040	0.7982	0.9973	0.4199	1.0569	0.9170	0.7775	0.5143	0.9500	0.7097
0.15	1.2242	1.2447	0.8343	1.1283	0.4457	1.6718*	0.7597	1.2758	0.6530	1.2232	0.8051
0.20	1.7438*	1.1368	1.3215	1.4225	0.6675	1.8729*	1.4356	0.8231	0.8148	1.2430	0.8891
0.25	2.0643**	1.2979	0.7583	0.9762	0.8393	1.9813**	1.5214	0.7687	0.6513	1.3560	1.0043
0.30	1.7106*	1.4656	0.9041	1.0545	0.7884	1.5495	1.3672	1.0052	0.6814	1.4375	1.2712
0.35	1.9293*	1.3598	0.4979	1.2271	1.1721	1.6995*	1.3177	0.7807	0.5967	1.3165	1.2825
0.40	1.6425	1.8785*	0.7123	1.0535	1.1435	1.7970*	1.9124*	0.9812	0.5656	1.4607	1.3537
0.45	1.4549	1.9020*	1.0235	1.1764	0.9873	1.9434*	1.6888*	1.1373	0.7143	1.5033	1.3512
0.50	1.1743	1.7758*	1.0376	1.1763	0.8385	1.7768*	1.6864*	1.5442	0.9819	1.4340	1.2649
0.55	1.5473	1.4655	1.0727	1.1799	1.0455	1.9498*	1.5168	1.1429	0.9746	1.6383	1.1584
0.60	1.3068	1.2095	1.5425	1.5602	0.8406	1.7871*	1.6909*	1.1143	0.9266	1.6911*	1.1288
0.65	0.8998	1.0632	1.2353	1.7952*	0.9247	1.5418	1.5321	1.2023	1.0773	1.5485	1.1750
0.70	0.9813	1.0838	0.9215	1.3917	1.0895	1.6079	1.5918	1.0478	0.8468	1.2899	1.1872
0.75	1.0139	1.1792	0.9314	1.2927	1.2879	1.6657*	1.4241	0.9010	0.7272	1.1130	1.1978
0.80	0.7298	0.7523	0.8011	1.0082	0.9949	1.3690	1.0017	0.5731	0.5733	0.9760	1.2298
0.85	0.4170	0.4815	0.7279	0.7956	0.5951	0.8006	0.6982	0.4669	0.5887	0.9767	0.7046
0.90	0.2935	0.5232	0.5526	0.5358	0.2634	0.4991	0.7541	0.4389	0.5331	0.8105	0.6755
0.95	0.2414	0.4853	0.3858	0.2919	0.3069	0.2231	0.2329	0.2881	0.3542	0.5142	0.3293

Notes: This table presents the numerical test statistics from the causality-in-quantile means on the predictive power of changes in the EU economic policy uncertainty (EEPU) on changes in the returns of EU sectoral stocks. The quantiles are captured under the heading: tau. The statistical significance levels of [5%] and [10%] for the respective critical values 1.96, and 1.645 are represented by ** and *, respectively for the various test statistics

Table 4 Causality-in-means analysis: USEPU and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	0.8189	0.9958	0.7916	0.6763	0.5424	0.8457	0.8154	0.5951	0.5194	0.8332	0.7823
0.10	0.7947	1.3293	0.9493	0.8590	0.4731	0.8335	1.2023	0.5221	0.6298	0.7822	1.0530
0.15	0.8448	1.2369	0.8084	1.0227	0.6019	1.2057	1.0422	1.0631	0.6081	0.8143	0.8157
0.20	1.2495	1.2668	1.1999	1.2600	0.4765	0.9613	1.0940	1.1418	0.7366	1.0056	0.8699
0.25	1.1132	1.1818	1.0309	1.0754	0.6251	1.3560	1.2665	1.0075	0.9889	0.8735	0.7951
0.30	0.9088	1.2898	1.0440	1.1134	0.6838	1.4169	1.4854	1.1963	0.9318	0.8588	0.7548
0.35	1.3195	1.1039	1.0250	1.1701	0.7134	1.3566	1.5817	1.2118	0.9180	1.1479	0.8625
0.40	1.1279	1.1544	1.0837	1.5533	0.5842	0.9562	1.2190	1.0778	0.9178	0.9443	0.9707
0.45	1.1757	1.1996	1.1673	1.4122	0.4435	1.0448	1.4066	1.0410	1.1361	1.1895	0.8754
0.50	1.0482	1.0228	1.1761	1.1690	0.5903	1.1307	1.5226	1.4165	1.0540	1.1601	0.8829
0.55	1.2807	0.7667	1.2024	1.0263	0.4714	1.2064	1.5175	1.5183	0.9389	1.3703	1.0908
0.60	1.2990	0.7967	1.2417	1.3048	0.5556	1.2672	1.1773	1.3928	0.9672	1.2111	1.0423
0.65	0.8473	0.8405	0.9515	1.4336	0.6698	1.4162	1.1052	1.2156	0.9684	1.1380	1.1568
0.70	0.9378	1.1863	1.1150	1.3658	0.8357	1.3325	1.0034	1.3678	0.7152	0.8977	1.2407
0.75	0.6018	1.3516	1.4860	1.3739	0.9565	1.2442	0.9776	1.2151	0.6503	0.8314	0.9620
0.80	0.5045	1.1179	1.4012	0.9432	0.8729	0.7625	0.9028	0.7543	0.8828	1.0343	0.9398
0.85	0.4148	1.2504	1.0644	0.8455	0.7423	0.6304	0.6782	1.0440	0.6648	0.9308	1.2703
0.90	0.5729	0.7786	0.7003	0.9300	0.3699	0.6693	0.4822	0.6250	0.5400	0.8158	0.9158
0.95	0.2583	0.8628	0.3989	0.3072	0.3487	0.3640	0.3098	0.2828	0.2374	0.8181	0.3255

Notes: This table presents the numerical test statistics from the causality-in-quantile means on the predictive power of changes in the economic policy uncertainty of the US (USEPU) on changes in the returns of EU sectoral stocks. The quantiles are captured under the heading: tau

Table 5 Causality-in-means analysis: GPR and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	0.9173	1.2155	0.9304	0.8722	0.3598	0.7809	0.7736	0.7243	0.5298	1.1410	0.6485
0.10	0.7910	1.5277	1.1952	1.0043	0.4328	1.1919	1.1940	0.9224	0.7936	0.9255	0.8703
0.15	0.8402	1.5125	1.0759	1.2380	0.4881	1.5749	1.3625	1.3509	1.0342	1.0784	0.7912
0.20	1.0826	1.3401	1.1037	1.9076*	0.6076	1.6828*	1.4588	1.2120	1.3197	1.2348	1.0185
0.25	1.2290	1.1099	1.3206	1.8378	0.6242	1.3844	1.7960*	1.3199	1.0578	1.0010	0.9870
0.30	1.1200	1.4240	1.1391	1.5749	0.8286	1.2558	1.8752*	1.4243	1.0739	1.0918	1.4536
0.35	1.5001	1.4349	0.9842	1.4500	0.7818	1.1351	1.8641*	1.3268	0.8756	1.1835	1.0276
0.40	2.0077**	1.2287	1.0117	1.2456	0.8405	1.1535	2.1697**	1.3584	1.0928	1.0664	0.9534
0.45	1.9330*	1.6244	1.2273	0.9519	0.9422	1.2421	1.7300*	0.9684	1.0464	1.2710	1.0812
0.50	2.3607**	1.5674	1.4313	0.9883	0.7745	1.4369	1.4994	1.8031*	0.9054	1.5163	1.1202
0.55	1.8151*	1.5535	1.3789	1.1611	0.7232	1.4764	1.1764	1.5335	0.8867	1.4913	1.1112
0.60	1.6345	1.2806	1.3283	1.1519	0.4893	1.1795	1.5913	1.4972	1.0167	1.3517	1.2005
0.65	1.5324	1.1111	0.9571	1.1098	0.9714	0.9543	1.1533	1.5133	0.9159	1.1922	1.3428
0.70	1.2457	1.2638	0.9639	1.0752	0.8175	1.1488	1.1775	1.5195	0.8051	1.3587	1.3045
0.75	1.0450	1.2922	1.1382	0.9220	0.3637	1.0264	1.3486	1.2159	0.7413	1.2031	0.8509
0.80	1.1206	1.4565	0.8008	0.7346	0.3115	0.6289	1.1095	1.0578	0.7426	0.6032	0.9161
0.85	1.3242	1.0781	0.2964	0.7397	0.3201	0.7687	0.7501	1.1227	0.7323	0.6025	0.8679
0.90	0.8458	0.5900	0.4677	0.5998	0.2673	0.6547	0.7464	0.5586	0.7142	0.8527	0.5303
0.95	0.1903	0.6513	0.3303	0.2268	0.1952	0.2341	0.1922	0.2829	0.3134	0.6988	0.1591

Notes: This table presents the numerical test statistics from the causality-in-quantile means on the predictive power of changes in geopolitical risk (GPR) on changes in the returns of EU sectoral stocks. The quantiles are captured under the heading: tau. The statistical significance levels of [5%] and [10%] for the respective critical values 1.96 and 1.645 are represented by ** and *, respectively for the various test statistics

Table 6 Causality-in-means analysis: VIX and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	0.7664	0.8903	0.6213	0.6937	0.4321	0.6328	0.8748	0.7539	0.5103	1.4193	0.7321
0.10	0.6359	1.1937	0.9065	0.8988	0.3898	0.8635	1.3277	0.6693	0.6991	1.3558	1.0449
0.15	0.9814	0.8570	0.6412	0.8129	0.3865	0.9354	1.1859	1.0899	0.7408	1.3160	0.9914
0.20	1.2508	0.7949	0.8207	0.9071	0.4885	0.8209	1.5482	0.9890	1.0042	1.0947	1.1534
0.25	1.2428	0.9523	1.0102	0.7522	0.7825	1.1609	1.6095	0.9727	1.1035	0.9824	0.8364
0.30	1.3642	1.1878	0.8691	0.8855	0.6603	0.8688	1.6287	0.8027	0.9922	1.0661	1.1208
0.35	1.7880*	1.0079	0.5722	0.9260	0.7094	0.9190	1.9618**	0.7272	1.5513	1.3414	1.4696
0.40	1.2898	1.2079	0.6772	1.0862	0.5959	0.8138	1.9068*	0.6900	1.4817	1.1399	1.5488
0.45	1.2402	1.4790	0.9787	1.3046	1.0299	0.9450	1.6949*	0.9254	1.2271	1.1414	1.7657*
0.50	1.3540	1.5199	1.0466	1.2580	1.6254	1.1465	1.9777**	1.3632	0.9273	1.2778	1.5030
0.55	1.0497	1.2949	1.1755	1.3242	1.5053	1.3398	2.2317**	1.3744	0.8178	1.1856	1.5423
0.60	0.9686	1.0089	1.6814	1.5092	1.5217	0.9738	1.6172	1.7103*	0.9422	0.9593	1.4528
0.65	0.7672	1.1350	1.3796	0.9611	1.2068	1.1048	1.8011*	1.7213*	1.0516	1.0825	1.5687
0.70	0.6443	1.1577	1.0520	0.9577	1.3497	1.0592	1.4870	1.6154	1.1476	1.0168	1.3626
0.75	0.7601	0.9742	1.1625	0.7329	1.1884	0.9757	1.3735	1.9454	0.7031	1.0318	1.2274
0.80	0.5934	0.8270	0.8895	0.5142	1.1718	0.8030	1.1421	1.6711	0.6265	1.1688	1.2806
0.85	0.7213	0.9434	1.0032	0.5759	1.0113	0.7601	0.8965	1.7589	0.5658	1.1309	1.2740
0.90	0.7864	1.0824	0.6396	0.7913	0.4752	0.6242	0.4591	0.6513	0.7092	1.1710	0.7941
0.95	0.3963	0.5886	0.4086	0.2898	0.2412	0.3365	0.2173	0.3156	0.3998	0.6009	0.5878

Notes: This table presents the numerical test statistics from the causality-in-quantile means on the predictive power of changes in investor sentiment (VIX) on changes in the returns of EU sectoral stocks. The quantiles are captured under the heading: tau. The statistical significance levels of [5%] and [10%] for the respective critical values 1.96 and 1.645 are represented by ** and *, respectively for the various test statistics

Table 7 Quantile regression analysis: GEPU and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	−0.0161***	−0.0160***	−0.0107***	−0.0179***	−0.0119***	−0.0152***	−0.0173***	−0.0203***	−0.0197***	−0.0147***	−0.0158***
0.10	−0.0118***	−0.0112***	−0.0087***	−0.0133***	−0.0093***	−0.0125***	−0.0128***	−0.0129***	−0.0161***	−0.0105***	−0.0095***
0.15	−0.0084***	−0.0087***	−0.0072***	−0.0109***	−0.0070***	−0.0083***	−0.0096***	−0.0094***	−0.0140***	−0.0083***	−0.0063***
0.20	−0.0062***	−0.0074***	−0.0050***	−0.0072***	−0.0056***	−0.0056***	−0.0077***	−0.0074***	−0.0119***	−0.0064***	−0.0049***
0.25	−0.0052***	−0.0058***	−0.0039***	−0.0056***	−0.0042***	−0.0041***	−0.0066***	−0.0043**	−0.0088***	−0.0060***	−0.0041***
0.30	−0.0040***	−0.0045***	−0.0027***	−0.0047***	−0.0032**	−0.0024*	−0.0046*	−0.0029**	−0.0066***	−0.0050***	−0.0032***
0.35	−0.0035***	−0.0029*	−0.0015**	−0.0030**	−0.0017	−0.0009	−0.0004	−0.0014	−0.0038**	−0.0034***	−0.0020**
0.40	−0.0013	−0.0003	−0.0008	−0.0010	0.0002	−0.0005	0.0006	−0.0004	−0.0026*	−0.0020*	−0.0011
0.45	0.0000	0.0009	0.0000	0.0005	0.0014	0.0002	0.0016*	0.0011	−0.0015	−0.0012	−0.0002
0.50	0.0012	0.0019	0.0006	0.0015	0.0022***	0.0014	0.0028**	0.0018**	−0.0005	0.0000	0.0003
0.55	0.0024***	0.0026***	0.0014*	0.0021**	0.0027***	0.0032***	0.0043***	0.0028***	0.0009	0.0005	0.0011
0.60	0.0028***	0.0034***	0.0021**	0.0037***	0.0035***	0.0040***	0.0052***	0.0039***	0.0015	0.0013	0.0030***
0.65	0.0036***	0.0045***	0.0030***	0.0051***	0.0045***	0.0050***	0.0065***	0.0049***	0.0031	0.0022**	0.0036***
0.70	0.0051***	0.0056***	0.0045***	0.0062***	0.0049***	0.0057***	0.0076***	0.0062***	0.0063***	0.0036***	0.0053***
0.75	0.0062***	0.0066***	0.0052***	0.0073***	0.0056***	0.0069***	0.0088***	0.0070***	0.0076***	0.0048***	0.0065***
0.80	0.0085***	0.0089***	0.0061***	0.0084***	0.0065***	0.0075***	0.0096***	0.0078***	0.0090***	0.0060***	0.0078***
0.85	0.0108***	0.0106***	0.0077***	0.0096***	0.0089***	0.0106***	0.0102***	0.0090***	0.0114***	0.0077***	0.0090***
0.90	0.0131***	0.0121***	0.0096***	0.0103***	0.0103***	0.0113***	0.0114***	0.0108***	0.0162***	0.0114***	0.0104***
0.95	0.0163***	0.0181***	0.0120***	0.0125***	0.0118***	0.0136***	0.0154***	0.0127***	0.0193***	0.0159***	0.0132***

Notes: This table presents the estimates from the quantile regression between global economic policy uncertainty (GEPU) and eleven EU sectoral stocks (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities). The quantiles are captured under the heading: tau. The statistical significance levels of [1%], [5%], and [10%] are represented by ***, **, and *, respectively

Table 8 Quantile regression analysis: EEPU and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	−0.0158***	−0.0152***	−0.0101***	−0.0177***	−0.0120***	−0.0141***	−0.0172***	−0.0192***	−0.0190***	−0.0143***	−0.0147***
0.10	−0.0112***	−0.0109***	−0.0082***	−0.0135***	−0.0087***	−0.0119***	−0.0121***	−0.0117***	−0.0149***	−0.0110***	−0.0090***
0.15	−0.0085***	−0.0087***	−0.0066***	−0.0105***	−0.0066***	−0.0078***	−0.0091***	−0.0088***	−0.0132***	−0.0082***	−0.0063***
0.20	−0.0061***	−0.0066***	−0.0051***	−0.0068***	−0.0055***	−0.0055***	−0.0075***	−0.0073***	−0.0111***	−0.0062***	−0.0048***
0.25	−0.0051***	−0.0055***	−0.0038***	−0.0057***	−0.0042***	−0.0038***	−0.0064***	−0.0040**	−0.0085***	−0.0056***	−0.0043***
0.30	−0.0041***	−0.0043***	−0.0025***	−0.0041***	−0.0031**	−0.0025**	−0.0043*	−0.0028**	−0.0067**	−0.0047***	−0.0030***
0.35	−0.0033***	−0.0028*	−0.0015**	−0.0027*	−0.0017	−0.0011	−0.0004	−0.0017	−0.0037**	−0.0031***	−0.0021***
0.40	−0.0012	−0.0003	−0.0007	−0.0010	0.0002	−0.0005	0.0006	−0.0004	−0.0025	−0.0019**	−0.0011
0.45	0.0000	0.0009	0.0000	0.0005	0.0013	0.0002	0.0016*	0.0010	−0.0014	−0.0012	−0.0002
0.50	0.0011	0.0020	0.0006	0.0015*	0.0020***	0.0013	0.0027**	0.0018**	−0.0005	−0.0002	0.0003
0.55	0.0022***	0.0026***	0.0015**	0.0022**	0.0026***	0.0029***	0.0041***	0.0027***	0.0009	0.0005	0.0012
0.60	0.0025***	0.0032***	0.0021**	0.0037***	0.0036***	0.0040***	0.0049***	0.0038***	0.0016	0.0013	0.0027**
0.65	0.0037***	0.0044***	0.0028***	0.0047***	0.0042***	0.0047***	0.0062***	0.0048***	0.0028	0.0023**	0.0035***
0.70	0.0052***	0.0053***	0.0045***	0.0058***	0.0049***	0.0058***	0.0072***	0.0060***	0.0063***	0.0036***	0.0051***
0.75	0.0060***	0.0063***	0.0053***	0.0067***	0.0055***	0.0066***	0.0086***	0.0069***	0.0074***	0.0048***	0.0067***
0.80	0.0086***	0.0087***	0.0062***	0.0081***	0.0064***	0.0073***	0.0091***	0.0077***	0.0087***	0.0058***	0.0073***
0.85	0.0107***	0.0100***	0.0075***	0.0087***	0.0085***	0.0094***	0.0104***	0.0091***	0.0105***	0.0069***	0.0089***
0.90	0.0135***	0.0113***	0.0096***	0.0107***	0.0101***	0.0120***	0.0114***	0.0101***	0.0153***	0.0103***	0.0096***
0.95	0.0156***	0.0165***	0.0109***	0.0122***	0.0112***	0.0132***	0.0155***	0.0126***	0.0195***	0.0156***	0.0129***

Notes: This table presents the estimates from the quantile regression between the EU economic policy uncertainty (EEPU) and eleven EU sectoral stocks (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities). The quantiles are captured under the heading: tau. The statistical significance levels of [1%], [5%], and [10%] are represented by ***, **, and *, respectively

Table 9 Quantile regression analysis: USEPU and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	−0.0175***	−0.0185***	−0.0114***	−0.0202***	−0.0133***	−0.0184***	−0.0206***	−0.0212***	−0.0221***	−0.0163***	−0.0174***
0.10	−0.0119***	−0.0126***	−0.0093***	−0.0156***	−0.0102***	−0.0137***	−0.0157***	−0.0133***	−0.0168***	−0.0125***	−0.0110***
0.15	−0.0092***	−0.0091***	−0.0079***	−0.0124***	−0.0084***	−0.0087***	−0.0106***	−0.0105***	−0.0156***	−0.0091***	−0.0077***
0.20	−0.0078***	−0.0082***	−0.0056***	−0.0079***	−0.0059***	−0.0067***	−0.0093***	−0.0078***	−0.0131***	−0.0080***	−0.0058***
0.25	−0.0055***	−0.0064***	−0.0046***	−0.0062***	−0.0051***	−0.0043***	−0.0066***	−0.0051***	−0.0088***	−0.0067***	−0.0046***
0.30	−0.0048***	−0.0043***	−0.0027***	−0.0049***	−0.0033**	−0.0029**	−0.0030	−0.0028*	−0.0069***	−0.0054***	−0.0032***
0.35	−0.0034**	−0.0034**	−0.0018**	−0.0029	−0.0017	−0.0009	−0.0002	−0.0017	−0.0043**	−0.0040***	−0.0021***
0.40	−0.0013	−0.0003	−0.0010	−0.0007	0.0002	−0.0003	0.0010	−0.0004	−0.0027**	−0.0021*	−0.0012
0.45	0.0000	0.0011	0.0000	0.0006	0.0016	0.0004	0.0018	0.0012	−0.0017	−0.0014	−0.0002
0.50	0.0017	0.0022***	0.0006	0.0016	0.0021**	0.0026*	0.0032***	0.0019*	−0.0005	0.0000	0.0003
0.55	0.0027***	0.0027***	0.0013	0.0025*	0.0032***	0.0038***	0.0044***	0.0032***	0.0013	0.0006	0.0013
0.60	0.0031***	0.0037***	0.0025**	0.0044***	0.0042***	0.0049***	0.0055***	0.0046***	0.0017	0.0016	0.0032***
0.65	0.0051***	0.0051***	0.0036***	0.0055***	0.0052***	0.0051***	0.0072***	0.0053***	0.0039*	0.0032**	0.0039***
0.70	0.0059***	0.0067***	0.0050***	0.0069***	0.0057***	0.0068***	0.0087***	0.0071***	0.0068***	0.0044***	0.0061***
0.75	0.0079***	0.0076***	0.0059***	0.0080***	0.0065***	0.0076***	0.0099***	0.0076***	0.0081***	0.0054***	0.0075***
0.80	0.0098***	0.0098***	0.0071***	0.0095***	0.0072***	0.0088***	0.0111***	0.0089***	0.0103***	0.0071***	0.0084***
0.85	0.0129***	0.0114***	0.0089***	0.0099***	0.0097***	0.0107***	0.0120***	0.0098***	0.0114***	0.0076***	0.0097***
0.90	0.0143***	0.0147***	0.0105***	0.0116***	0.0119***	0.0133***	0.0131***	0.0119***	0.0185***	0.0113***	0.0125***
0.95	0.0177***	0.0188***	0.0125***	0.0164***	0.0139***	0.0145***	0.0171***	0.0159***	0.0217***	0.0178***	0.0147***

Notes: This table presents the estimates from the quantile regression between economic policy uncertainty of the US (USEPU) and eleven EU sectoral stocks (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities). The quantiles are captured under the heading: tau. The statistical significance levels of [1%], [5%], and [10%] are represented by ***, **, and *, respectively

Table 10 Quantile regression analysis: GPR and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	−0.0173***	−0.0179***	−0.0121***	−0.0204***	−0.0145***	−0.0169***	−0.0202***	−0.0225***	−0.0224***	−0.0164***	−0.0174***
0.10	−0.0116***	−0.0126***	−0.0097***	−0.0156***	−0.0100***	−0.0137***	−0.0146***	−0.0135***	−0.0176***	−0.0129***	−0.0108***
0.15	−0.0095***	−0.0106***	−0.0077***	−0.0119***	−0.0077***	−0.0088***	−0.0104***	−0.0101***	−0.0158***	−0.0100***	−0.0072***
0.20	−0.0079***	−0.0081***	−0.0054***	−0.0079***	−0.0057***	−0.0065***	−0.0083***	−0.0084***	−0.0119***	−0.0073***	−0.0054***
0.25	−0.0061***	−0.0061***	−0.0043***	−0.0070***	−0.0048***	−0.0045***	−0.0070***	−0.0060***	−0.0096***	−0.0061***	−0.0048***
0.30	−0.0048***	−0.0050***	−0.0028***	−0.0051***	−0.0032**	−0.0029**	−0.0046**	−0.0031*	−0.0087***	−0.0056***	−0.0034***
0.35	−0.0037***	−0.0033*	−0.0018**	−0.0032**	−0.0020	−0.0014	−0.0004	−0.0020	−0.0045*	−0.0037***	−0.0024**
0.40	−0.0016	−0.0016	−0.0010	−0.0012	0.0002	−0.0006	0.0005	−0.0005	−0.0030**	−0.0022**	−0.0013
0.45	−0.0001	0.0008	−0.0002	0.0003	0.0016	−0.0001	0.0018*	0.0011	−0.0015	−0.0016	−0.0003
0.50	0.0012	0.0018*	0.0006	0.0016*	0.0027***	0.0015	0.0030**	0.0018**	−0.0009	−0.0002	0.0002
0.55	0.0026**	0.0030***	0.0015*	0.0023*	0.0032***	0.0033**	0.0047***	0.0027**	0.0009	0.0006	0.0011
0.60	0.0029***	0.0037***	0.0024***	0.0037***	0.0040***	0.0042***	0.0054***	0.0041***	0.0020	0.0014	0.0033**
0.65	0.0041***	0.0048***	0.0033***	0.0056***	0.0049***	0.0052***	0.0073***	0.0055***	0.0033	0.0027**	0.0039***
0.70	0.0059***	0.0057***	0.0048***	0.0068***	0.0059***	0.0065***	0.0085***	0.0067***	0.0068***	0.0043***	0.0052***
0.75	0.0071***	0.0074***	0.0059***	0.0081***	0.0066***	0.0079***	0.0098***	0.0082***	0.0088***	0.0055***	0.0075***
0.80	0.0109***	0.0102***	0.0072***	0.0094***	0.0077***	0.0083***	0.0106***	0.0087***	0.0101***	0.0073***	0.0085***
0.85	0.0121***	0.0120***	0.0085***	0.0102***	0.0093***	0.0111***	0.0125***	0.0106***	0.0127***	0.0083***	0.0100***
0.90	0.0156***	0.0135***	0.0119***	0.0131***	0.0120***	0.0147***	0.0138***	0.0126***	0.0183***	0.0129***	0.0119***
0.95	0.0195***	0.0184***	0.0130***	0.0147***	0.0129***	0.0159***	0.0192***	0.0159***	0.0217***	0.0181***	0.0154***

Notes: This table presents the estimates from the quantile regression between geopolitical risk (GPR) and eleven EU sectoral stocks (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities). The quantiles are captured under the heading: tau. The statistical significance levels of [1%], [5%], and [10%] are represented by ***, **, and *, respectively

Table 11 Quantile regression analysis: VIX and sectoral stocks from the EU

Tau	Consumer discretionary	Consumer services	Consumer staples	Financials	Healthcare	Industrials	Information technology	Materials	Oil and gas	Telecom	Utilities
0.05	−0.1238***	−0.0996***	−0.1028***	−0.1166***	−0.0953***	−0.1223***	−0.1520***	−0.1337***	−0.1329***	−0.0813***	−0.0634***
0.10	−0.1238***	−0.0960***	−0.1028***	−0.1166***	−0.0953***	−0.1223***	−0.1520***	−0.1337***	−0.1329***	−0.0813***	−0.0634***
0.15	−0.1238***	−0.0960***	−0.1028***	−0.1166***	−0.0953***	−0.1121***	−0.1520***	−0.1337***	−0.1329***	−0.0813***	−0.0634***
0.20	−0.1238***	−0.0960***	−0.1028***	−0.1166***	−0.0953***	−0.1121***	−0.1520***	−0.1337***	−0.1329***	−0.0813***	−0.0634***
0.25	−0.1238***	−0.0960***	−0.1028***	−0.1166***	−0.0953***	−0.1121***	−0.1520***	−0.1337***	−0.1329***	−0.0813***	−0.0634***
0.30	−0.1238***	−0.0960***	−0.1028***	−0.1166***	−0.0945***	−0.1121***	−0.1479***	−0.1337***	−0.1214***	−0.0722***	−0.0634***
0.35	−0.1238***	−0.0960***	−0.1028***	−0.1166***	−0.0945***	−0.1121***	−0.1479***	−0.1337***	−0.1214***	−0.0722***	−0.0634***
0.40	−0.1238***	−0.0960***	−0.0964***	−0.1166***	−0.0945***	−0.1121***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.45	−0.1238***	−0.0960***	−0.0964***	−0.1166***	−0.0945***	−0.1121***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.50	−0.1238***	−0.0960***	−0.0964***	−0.1166***	−0.0945***	−0.1121***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.55	−0.1238***	−0.0960***	−0.0964***	−0.1166***	−0.0945***	−0.1121***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.60	−0.1238***	−0.0960***	−0.0964***	−0.1166***	−0.0945***	−0.1114***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.65	−0.1190***	−0.0918***	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.70	−0.1190***	−0.0918***	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.75	−0.1107***	−0.0918***	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1479***	−0.1299***	−0.1214***	−0.0722***	−0.0617***
0.80	−0.1065***	−0.0918***	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1479***	−0.1299***	−0.1195***	−0.0722***	−0.0617***
0.85	−0.1065***	−0.0918***	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1479***	−0.1299***	−0.1195***	−0.0718***	−0.0611***
0.90	−0.1065***	−0.0918***	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1445***	−0.1299***	−0.1195***	−0.0718***	−0.0611***
0.95	−0.1065***	−0.0918**	−0.0897***	−0.1126***	−0.0945***	−0.1114***	−0.1445***	−0.1299***	−0.1195***	−0.0709***	−0.0611***

Notes: This table presents the estimates from the quantile regression between investor sentiment (VIX) and eleven EU sectoral stocks (consumer discretionary, consumer services, consumer staples, financials, healthcare, industrials, information technology, materials, oil and gas, telecom, and utilities). The quantiles are captured under the heading: tau. The statistical significance levels of [1%], [5%], and [10%] are represented by ***, **, and *, respectively

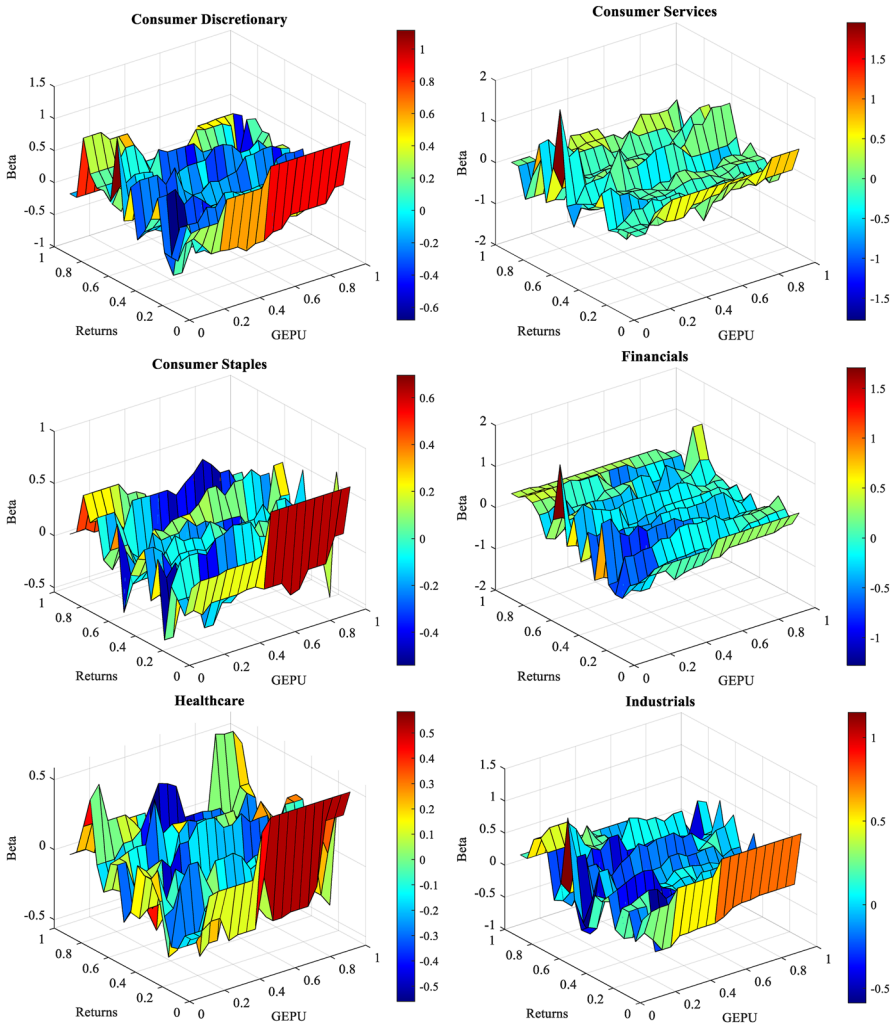


Fig. 7 QQR analysis: GEPU and EU sectoral stocks. Notes: This figure shows the 3D plots of the beta estimates from the quantile-on-quantile regression between global economic policy uncertainty (GEPU) and EU sectoral stocks. The z-axis of each plot gauges the beta estimates while the x- and y-axes keep track of the quantiles of GPR and stock returns, respectively (color figure online)

various sectors could serve as a hedge only when the market condition is bearish for both stock returns and GPR. That is, EU stocks may not be a hedge only when GPR is in a bullish condition (0.75–0.95) whilst stock returns are in a bearish condition (0.05–0.20). Thus, in a coincidence between amplifying levels of GPR and worse periods of stock markets, the EU stocks may fail to withstand the downside risk of GPR. Therefore, we refer to Bossman et al. (2023a, 2023b, 2023c) and Umar et al. (2022a, 2022b), who emphasize that managing GPR at its normal or lower levels will be beneficial for financial markets.

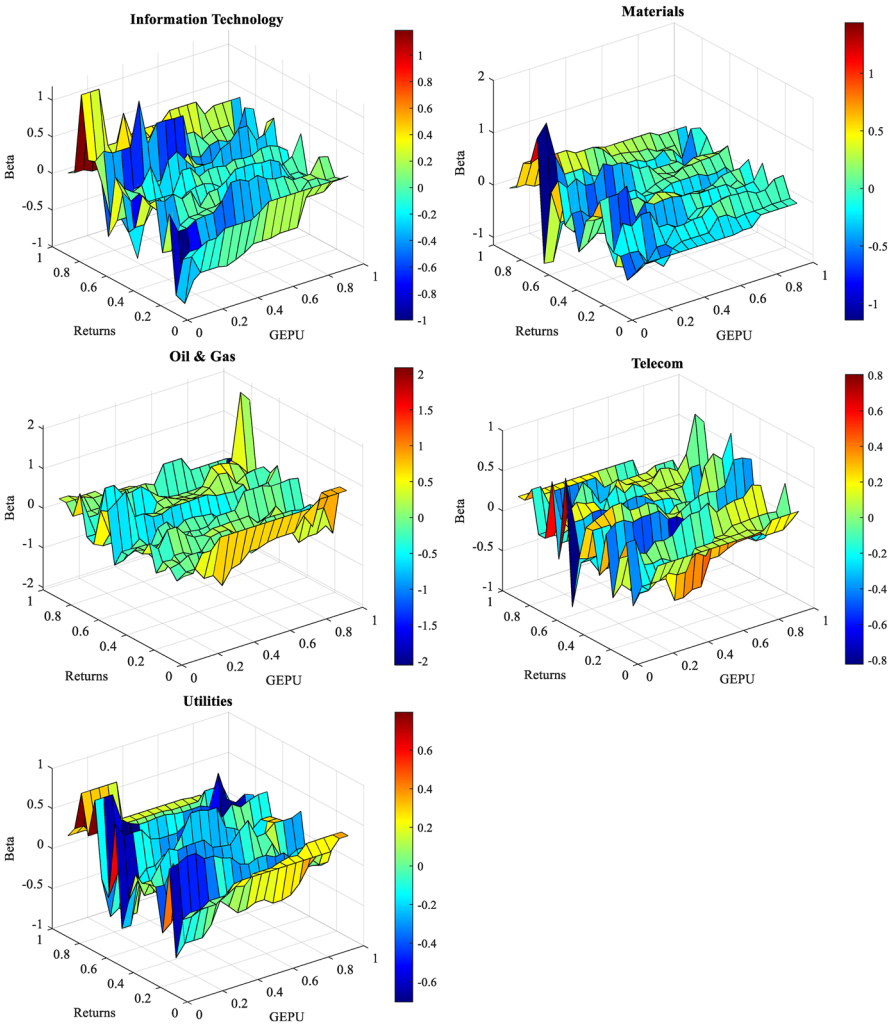


Fig. 7 (continued)

Figure 11 presents the relationship between investor sentiment (VIX) and EU sectoral stocks. The relationships between VIX and EU sectoral stocks across most quantiles are negative, indicating the VIX's position as a hedge against the downside risks of the EU stocks. However, we note that VIX and various stocks are positively related across the upper quantiles (0.90–0.95) of stock returns and mainly lower quantiles of VIX. This suggests that during stock markets' bullish conditions, VIX fails to serve as a hedge for the downside risk of the EU stocks. Note that, among the sectors, the VIX partially serves as a consistent hedge for consumer discretionary, consumer services, and financials.

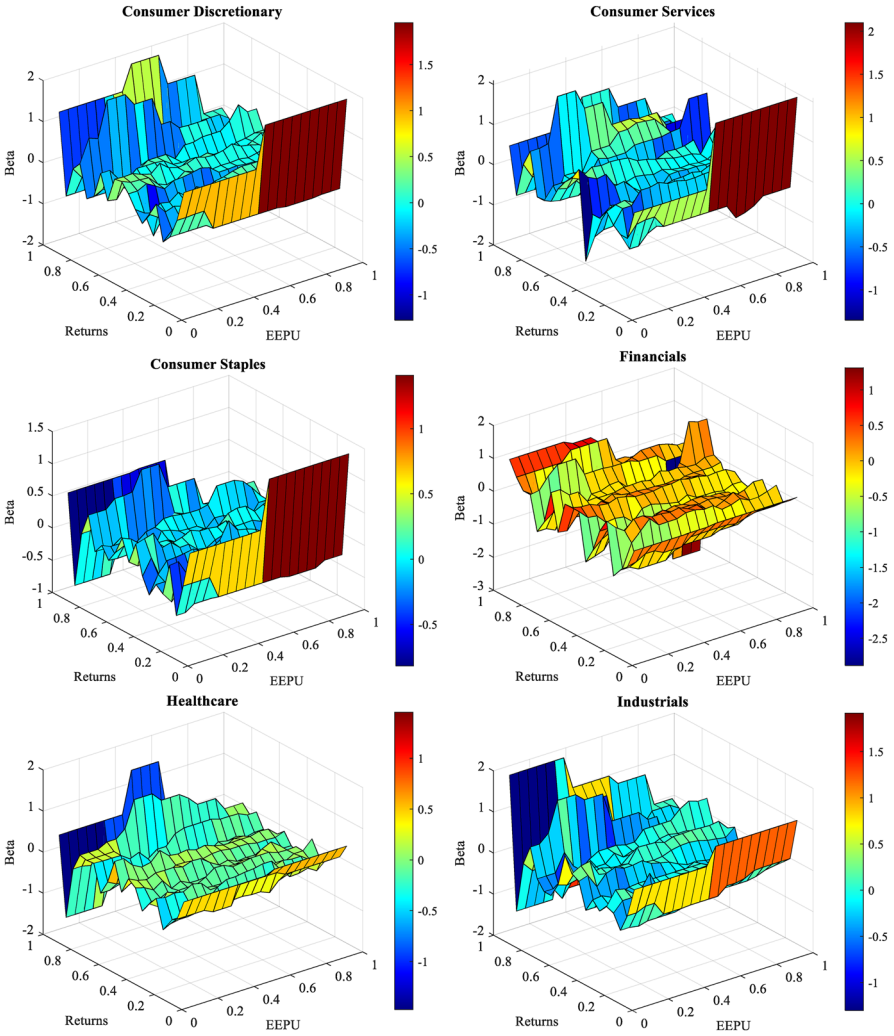


Fig. 8 QQR analysis: EEPU and EU sectoral stocks. Notes: This figure shows the 3D plots of the beta estimates from the quantile-on-quantile regression between the EU economic policy uncertainty (EEPU) and EU sectoral stocks. The z-axis of each plot gauges the beta estimates while the x- and y-axes keep track of the quantiles of GPR and stock returns, respectively (color figure online)

In what concerns policy implications and analysis in the context of COVID-19, the visual investigation of Figs. 7, 8, 9, 10 and 11 allows us to identify the regions of the chars that correspond to the pandemic expansion, as the locations, which are characterized by low levels of returns and high levels of EPU, GPR and VIX. Amidst the COVID-19 outbreak expansion, aggressive social-distancing measures and lockdowns have negatively impacted the performance of capital markets (Gubareva, 2021a, 2021b). Our results corroborate with the previous studies providing insights for designing and implementing policies capable of

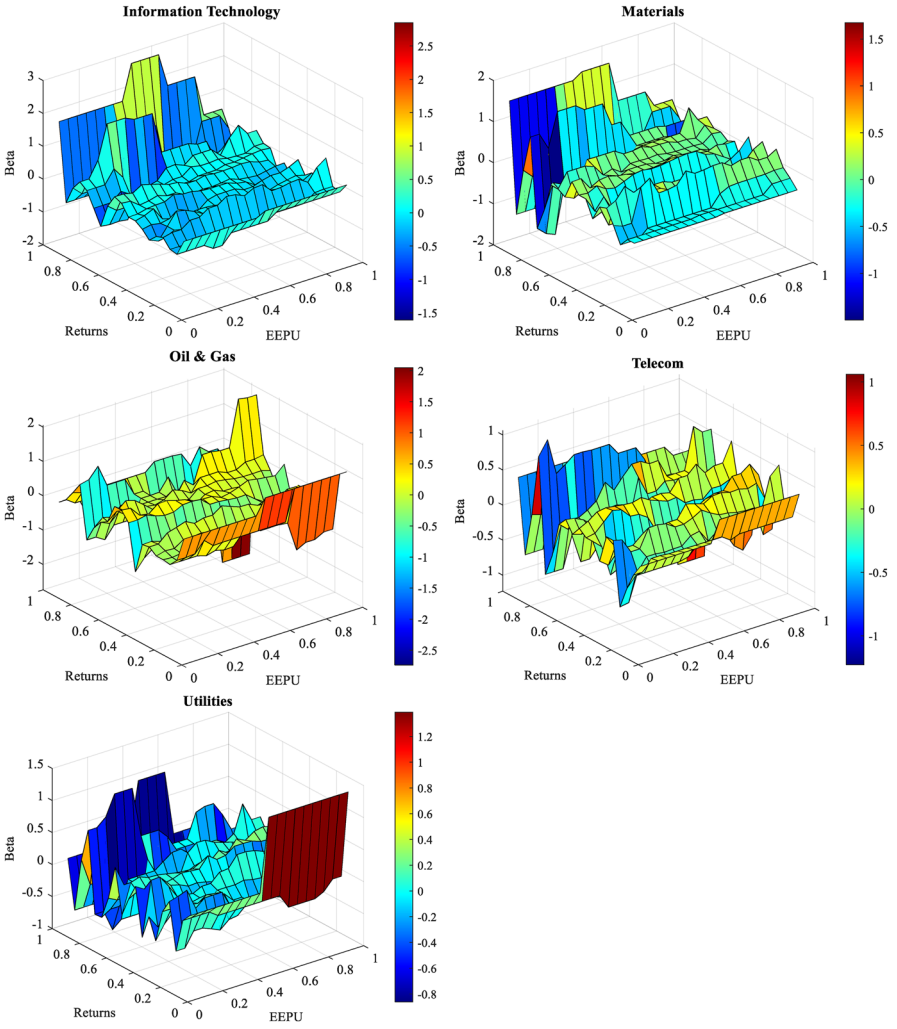


Fig. 8 (continued)

withstanding severe financial stresses transversal to the global market similar to COVID-19 and enabling the countries and the regions to recover by properly addressing severe systemic crises. Once again, we reiterate that among the sectors, the VIX partially serves as a consistent hedge for consumer discretionary, consumer services, and financials. However, a certain caution should be taken in order not to assume automatically that what has been found to work during the COVID-19 pandemic, will be workable during future disease-driven or economy-driven stress episodes, as hedge strategies feasible for normal market conditions may fail during periods of global crisis (Umar & Gubareva, 2020). Wrapping up, the effect of major policies, implemented by governments to mitigate

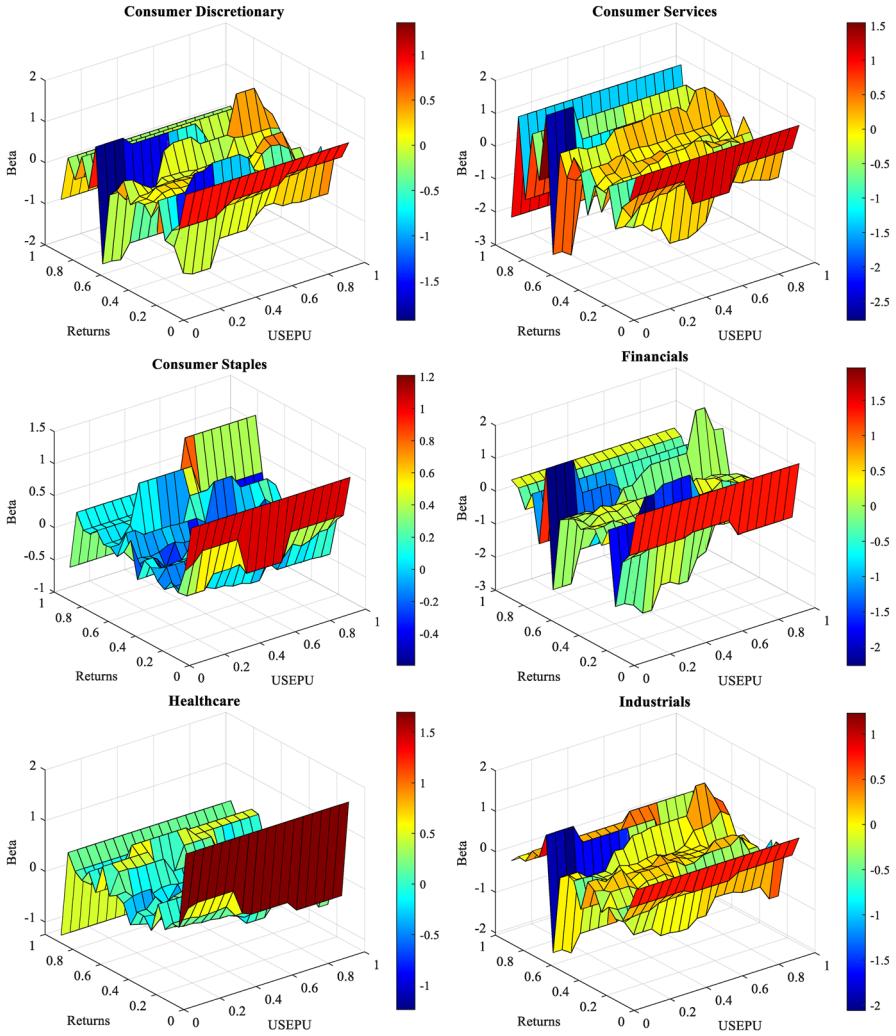


Fig. 9 QQR analysis: USEPU and EU sectoral stocks. Notes: This figure shows the 3D plots of the beta estimates from the quantile-on-quantile regression between the economic policy uncertainty of the US (USEPU) and EU sectoral stocks. The z-axis of each plot gauges the beta estimates while the x- and y-axes keep track of the quantiles of GPR and stock returns, respectively (color figure online)

the effects of the COVID-19 pandemic have produced positive effects on GDP on a country, regional and global level. By large, the most important policies are social distancing, financial help to businesses and households, and vaccination along with ejecting liquidity by central banks on financial markets, cutting interest rates, and implementing quantitative easing (Haddad et al., 2021; Hartley & Rebucci, 2020). The large-scale policy responses have softened the COVID-19 adverse effects on EM liquidity (Gubareva, 2021a, 2021b). In line with the above-cited studies, our results indicate that the returns of EU stock markets

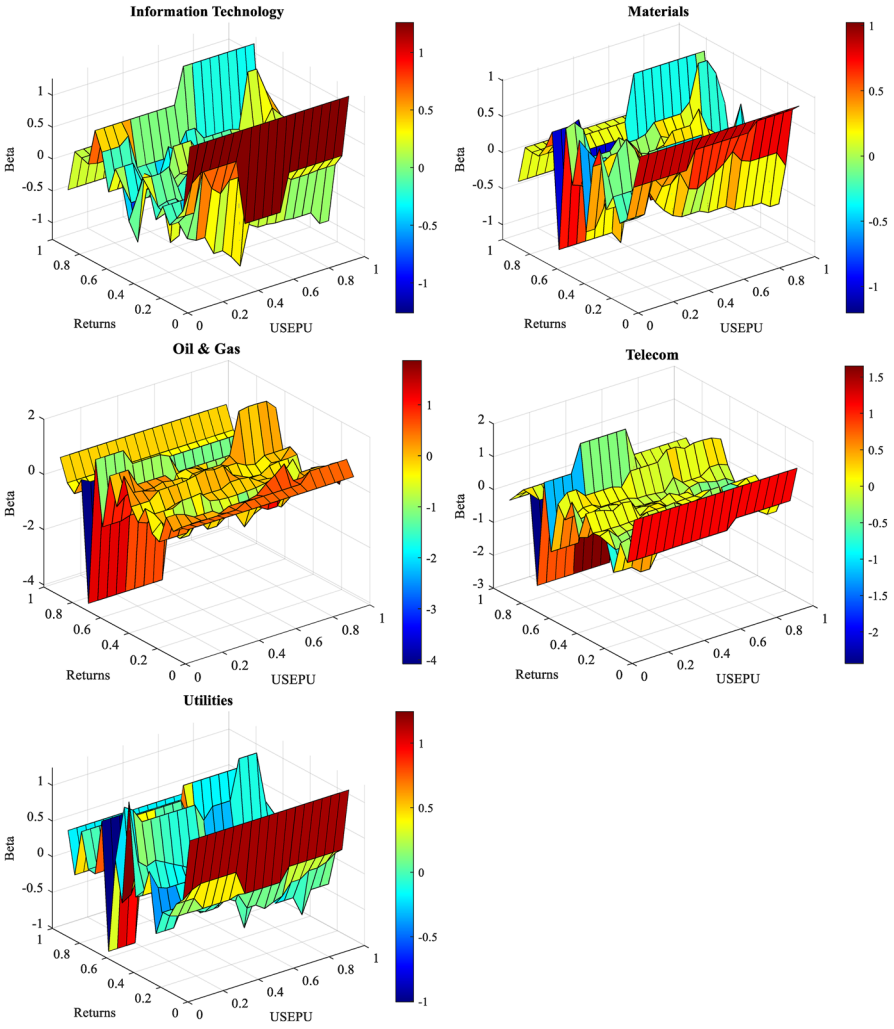


Fig. 9 (continued)

and the impacts of policies depend on the overall market situation and might vary over time and sectors of economic activity. Therefore, it is of extreme importance that the governments keep analyzing adherence of their strategies to the state of economies and capital markets in order to ensure the efficiency of their policies. Corroborating with Albaity et al. (2023), and extending the investigation to the EU economic zone, our results offer valuable COVID-19-related insights into the heterogeneity of market conditions and dependencies of EU stock returns on investor sentiment, geopolitical risk, and economic policy uncertainty.

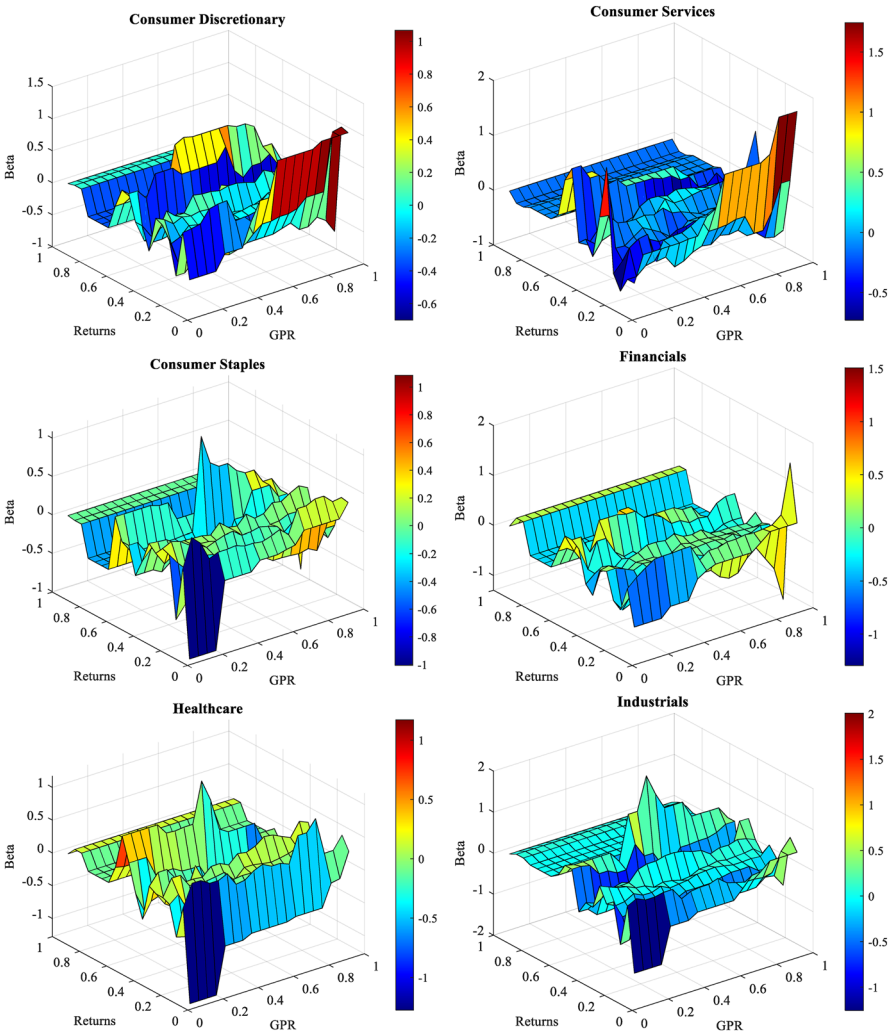


Fig. 10 QQR analysis: GPR and EU sectoral stocks. Notes: This figure shows the 3D plots of the beta estimates from the quantile-on-quantile regression between geopolitical risk (GPR) and EU sectoral stocks. The z-axis of each plot gauges the beta estimates while the x- and y-axes keep track of the quantiles of GPR and stock returns, respectively (color figure online)

4.4 Robustness

In this sub-section, we ascertain the validity of the estimates from the nonparametric QQR approach based on those from its parametric counterpart, the QR approach. Since the QR approach follows a set of parametric steps, the significance of the estimates is easily generated. The QQR approach, however, follows a set of nonparametric steps and, as a result, the conventional means of ascertaining the significance of the estimates is to compare them with their QR counterparts. Due to the fact that

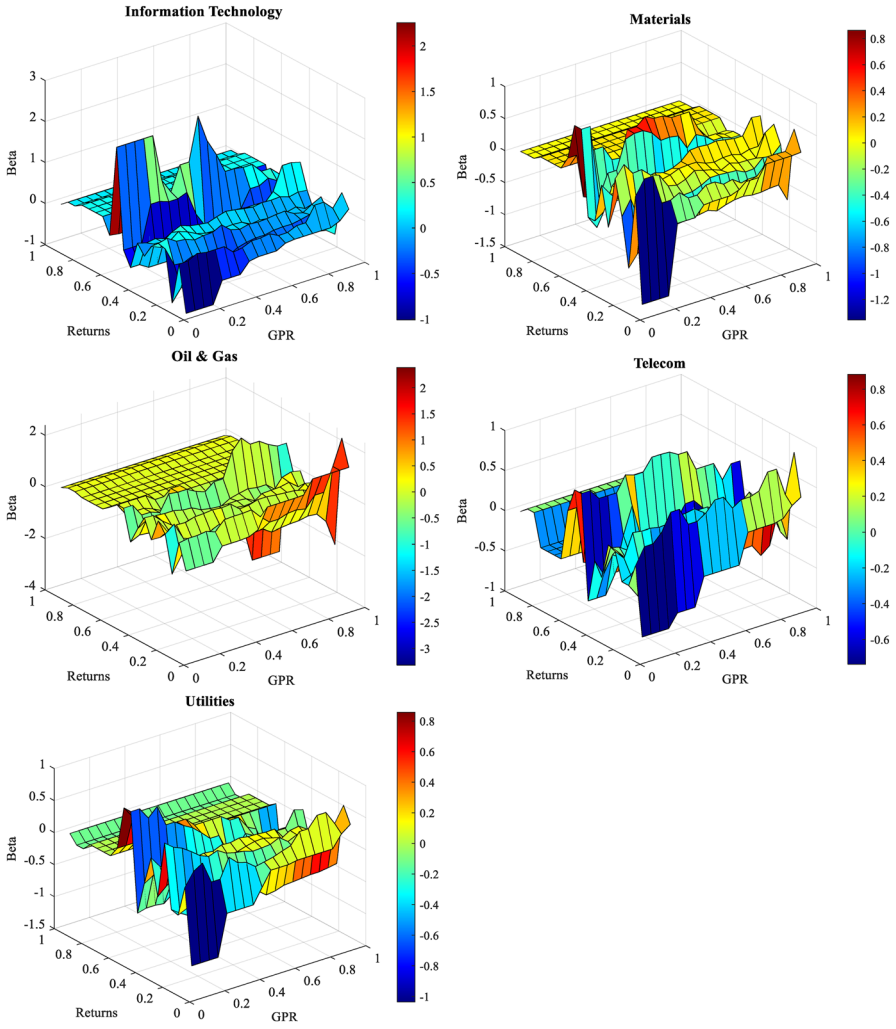


Fig. 10 (continued)

the QQR converges to the QR, the significance of the QQR estimates, hence, robustness, is confirmed when the trajectories portrayed by the QQR estimates bear resemblance with their QR counterparts (Agyei, 2022; Alsubaie et al., 2022; Khan et al., 2022). Therefore, in this sub-section, we ascertain how robust the QQR estimates are to their QR counterparts by presenting the results in line graphs. Figures 12, 13, 14, 15 and 16 demonstrate this for GEPU, EEPU, USEPU, GPR, and VIX, respectiv ely.

From the various plots, we document a high resemblance of QR and QQR estimates, as shown by the overlap between blue (QQR) and orange (QR) estimates. The few differences in the QR and QQR estimates result from possible

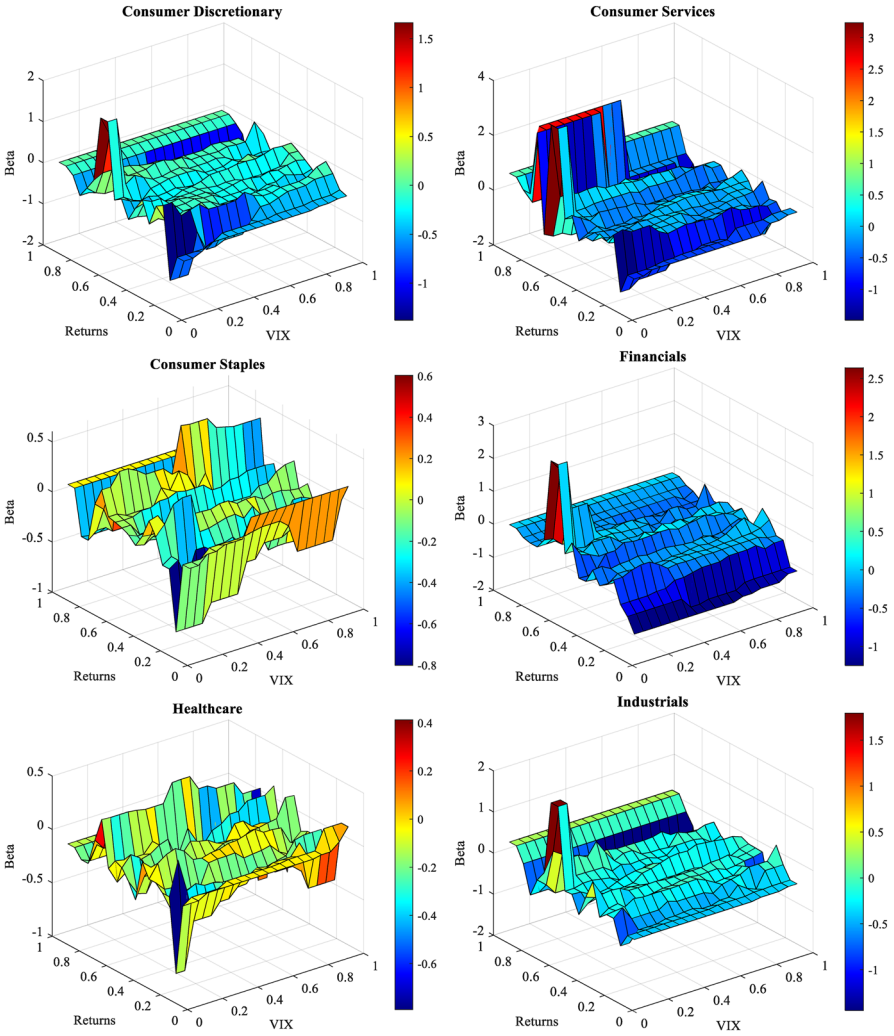


Fig. 11 QQR analysis: VIX and EU sectoral stocks. Notes: This figure shows the 3D plots of the beta estimates from the quantile-on-quantile regression between investor sentiment (VIX) and EU sectoral stocks. The z-axis of each plot gauges the beta estimates while the x- and y-axes keep track of the quantiles of GPR and stock returns, respectively (color figure online)

noise effects (Pang et al., 2022; Umar et al., 2023a). Put differently, Pang et al. (2022) and Umar et al. (2023a, 2023b) explain that modest differences between QR and QQR estimates result from possible noise effects and, thus, do not compromise the robustness of the reported results.

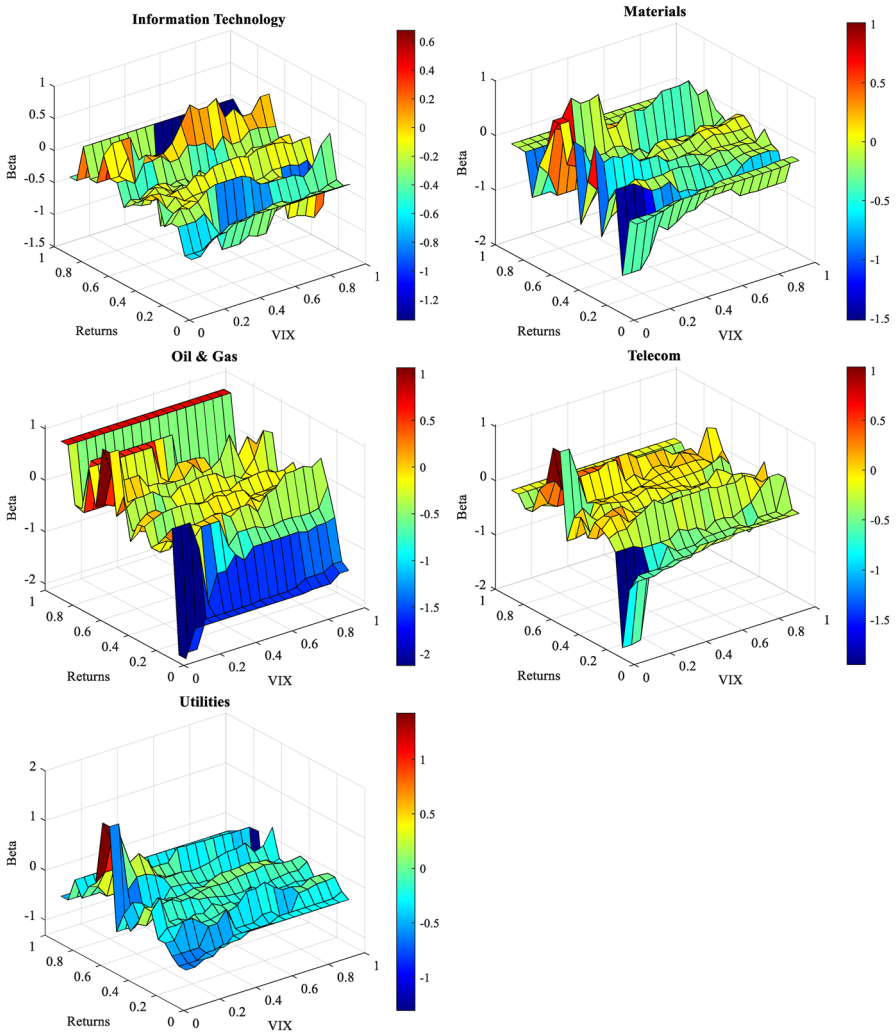


Fig. 11 (continued)

5 Concluding remarks

This paper analyzes the asymmetric effects of economic policy uncertainty, geopolitical risk, and investor sentiment on EU stocks from various sectors of economic activity. We gauge asymmetries in the dynamics of returns produced by various EU sectors at elevated levels of economic policy uncertainty, geopolitical risk, and market sentiment using the causality-in-quantile-means analysis. Afterwards, we analyze the safe-haven and hedge attributes of EU stocks against global economic policy (EPU) uncertainty as well as against European Union EPU and United States EPU. We also explore the safe-haven and hedge attributes of investor sentiment,

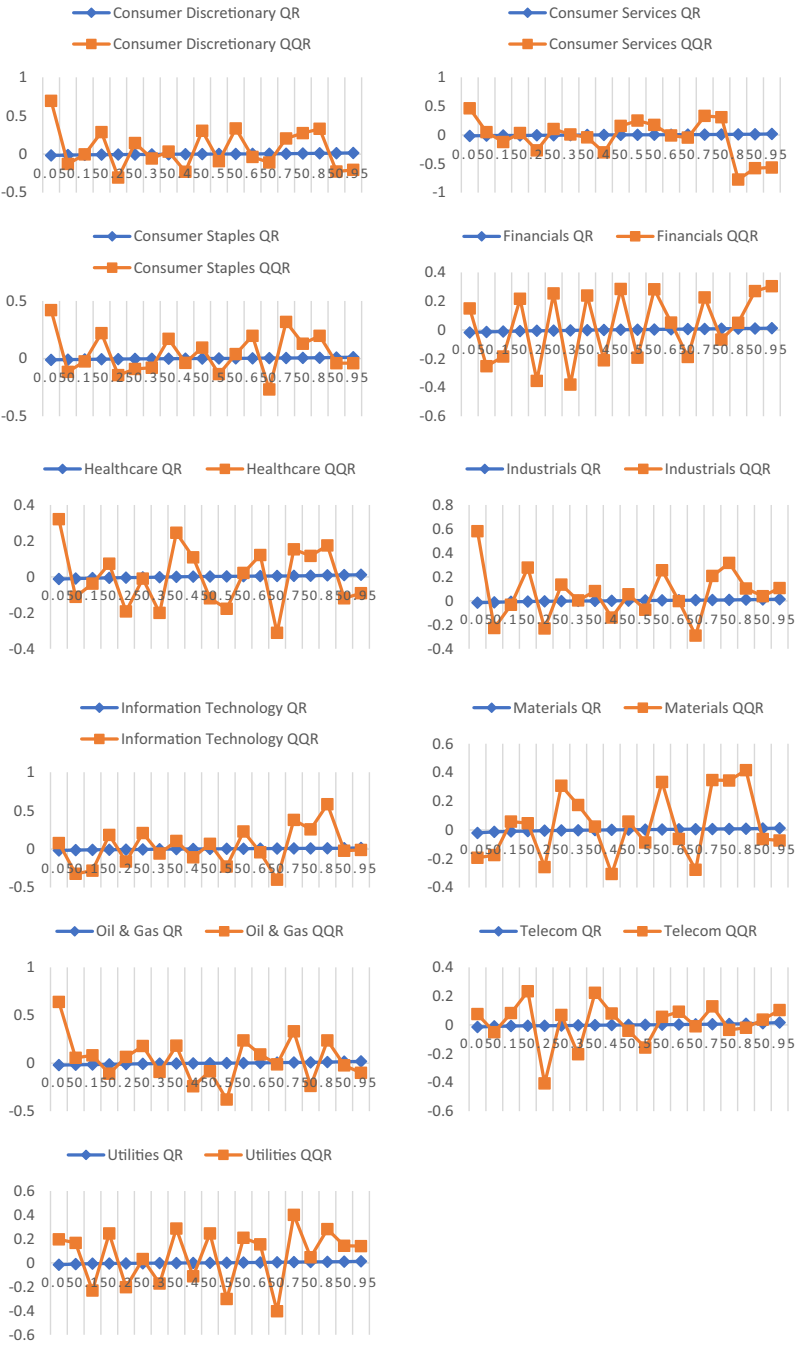


Fig. 12 QR and QQR slopes: GEPU and EU sectoral stocks. Notes: This figure shows line plots of the beta estimates from quantile regression (QR) and quantile-on-quantile regression (QQR) between geopolitical risk (GPR) and EU sectoral stocks. The vertical axis of each plot measures the beta estimates while the horizontal axis keeps track of the quantiles. Blue (orange) trends represent the QR (QQR) estimates (color figure online)

Fig. 13 QR and QQR slopes: EEPU and EU sectoral stocks. Notes: This figure shows line plots of the beta estimates from quantile regression (QR) and quantile-on-quantile regression (QQR) between EU economic policy uncertainty (EEPU) and EU sectoral stocks. The vertical axis of each plot measures the beta estimates while the horizontal axis keeps track of the quantiles. Blue (orange) trends represent the QR (QQR) estimates (color figure online)

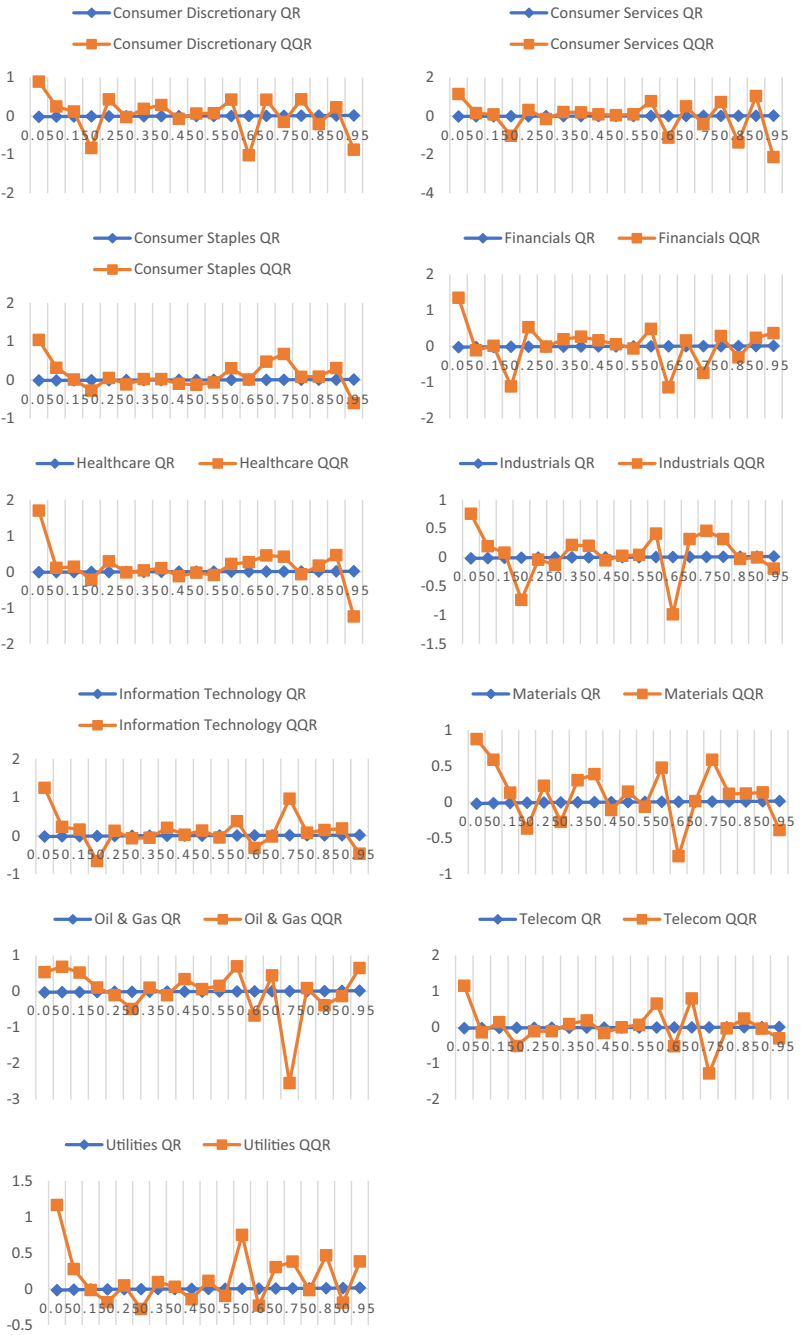


Fig. 14 QR and QQR slopes: USEPU and EU sectoral stocks. Notes: This figure shows line plots of the beta estimates from quantile regression (QR) and quantile-on-quantile regression (QQR) between economic policy uncertainty of the US (USEPU) and EU sectoral stocks. The vertical axis of each plot measures the beta estimates while the horizontal axis keeps track of the quantiles. Blue (orange) trends represent the QR (QQR) estimates (color figure online)

Fig. 15 QR and QQR slopes: GPR and EU sectoral stocks. Notes: This figure shows line plots of the beta estimates from quantile regression (QR) and quantile-on-quantile regression (QQR) between geopolitical risk (GPR) and EU sectoral stocks. The vertical axis of each plot measures the beta estimates while the horizontal axis keeps track of the quantiles. Blue (orange) trends represent the QR (QQR) estimates (color figure online)

Fig. 16 QR and QQR slopes: VIX and EU sectoral stocks. Notes: This figure shows line plots of the beta estimates from quantile regression (QR) and quantile-on-quantile regression (QQR) between investor sentiment (VIX) and EU sectoral stocks. The vertical axis of each plot measures the beta estimates while the horizontal axis keeps track of the quantiles. Blue (orange) trends represent the QR (QQR) estimates (color figure online)

as measured by the CBOE VIX index, and of geopolitical, as gauged by the GPR index, against various sectoral stocks from the EU using the quantile regression and quantile-on-quantile regression techniques.

The series of analyses undertaken in the study produce important findings. We demonstrate that economic policy uncertainty and geopolitical risk have asymmetric causal influence and relationships with the EU stocks from different sectors of economic activity. The influence of the EU economic policy uncertainty on sectoral stocks is highly significant relative to the influence of the US economic policy uncertainty. Notwithstanding, certain EU sectoral stocks, found to serve just as diversifiers in normal market conditions, fail to serve as a hedge in stressed periods. However, with respect to geopolitical instability, the EU stocks could serve as hedges and safe-havens against GPR in bearish periods of economic activity. Furthermore, the empirical findings suggest that market sentiment is a good means for hedging against the downside shocks associated with the EU stocks from various sectors.

The findings from the present study have significant implications for investors, portfolio management practitioners, and future studies. To ensure that regulatory measures are effective and proactive, regulators would need to incorporate the role of regional and global factors that contribute to economic policy uncertainty. Through this, the policy trends in the EU economy could be a necessary factor to be considered when formulating policy measures for various EU sectors of economic activity. Similarly, for investors and risk managers, these findings highlight two important issues—first, to hedge against the extreme risks of the EU economy, portfolio managers concerned with EU-dominated assets may have to gauge investor sentiment and incorporate appropriate safe-haven and hedge assets from different markets, particularly in stressed periods of economic activity; and second, the asymmetric relationships between the stock volatility, investor sentiment, and various sectoral stocks highlight the need for cross-asset and cross-sector investments to mitigate overall portfolio risks. Future contributions to the literature could extend the findings presented in the present study by analyzing the portfolio implications of investments containing EU assets in the presence of economic policy uncertainty and geopolitical risk.

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Data availability The data used to support the findings of this study are available upon request.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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