FORECASTING REAL ECONOMIC ACTIVITY AND INFLATION: THE ROLE OF GEOPOLITICAL RISKS AND ECONOMIC POLICY UNCERTAINTY IN MAJOR ECONOMIES

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Author: Amaya Hundal
Subject: Banking and International Finance
Supervisor: Juha-Pekka Junttila

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

ABSTRACT

Author Amaya Hundal	
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Abstract

The increasing prominence of geopolitical risks and economic policy uncertainties globally has brought their impacts on overall economies to the forefront in both academia and policymaking. Current literature, while being rich in focus on economic policy uncertainty, represented by the EPU index, and financial and macroeconomic variables, is limited in research exploring the dynamics of geopolitical risks, represented by the GPR index, and is even more so limited in research offering a comparison of the two indices in terms of their forecasting content for real economic activity and inflation. This thesis focuses on the interactions between the global GPR index, the global EPU index, 3-month money market interest rate, term spread, dividend yield, real economic activity, and inflation, for Germany, the UK, and the US, through a VAR analysis whereby causal relationships and dynamic interactions are brought to the forefront. Furthermore, rolling out-of-sample forecasts for real economic activity and inflation are conducted based on models of conventional financial market variables and models augmented with the GPR and EPU indices in addition to the conventional variables. Results indicate causality between the EPU index and the macroeconomy to flow through the financial market variables with no significant causal relationships found with the GPR index. Significant relationships are found between the EPU index, and dividend yield, 3-month money market interest rate, and term spread of all three countries, as well as between the EPU index and real economic activity of Germany and the US, by Granger causality tests, impulse response functions, and variance decompositions. The VAR-based forecasts, however, indicate the superiority of the model augmented with the GPR index in addition to conventional financial market variables, given by a small margin, in yielding accurate forecasts of real economic activity for Germany, the UK, and the US, over that of conventional financial market variables and the models inclusive of the EPU index. Thus, the importance of understanding the dynamic interactions between economic policy uncertainty, the financial markets, and the economy is highlighted, and the relevance of geopolitical risks is emphasised in forecasting future real economic activity.

Key words

Macroeconomic forecasting, Financial Markets, Economic policy uncertainty, Geopolitical risks

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1 INTRODUCTION

1.1 Background

Geopolitical risks have come under significant attention since the invasion of Ukraine by Russia in early 2022. While the direct impacts of the war on the lives of millions are evident, considerable upsets have also ensued through more indirect channels, specifically in the form of adverse conditions in financial markets and economies, especially in Europe. Inflationary highs, rising interest rates, recessionary outlooks, and crises around energy, food, and cost of living, have been catalysed by Russia's invasion of Ukraine. Thus, the relevance of exogenous geopolitical shocks on financial markets and the macroeconomy is highlighted.

How exactly do geopolitical risks and uncertainties change the shape of economies? This is the key question arisen by the current economic conditions in Europe. The (IMF, 2022a, 2022b) points towards rising geopolitical risks as a key factor in heightening vulnerabilities in global financial systems and diminishing their stability, in addition to doing their part in bringing down economic growth forecasts over the 2020-2023 period by 3.3 percentage points. The European Central Bank (2022) discusses the defining role of the Russo-Ukrainian geopolitical tensions in bringing forth instability across the financial, macroeconomic, credit and banking environments. Bank of England highlights geopolitical uncertainty in tandem with economic and policy uncertainties as determinants of economic performance (Carney, 2016).

Caldara & Iacoviello (2022) provide the means to delve into the linkages between geopolitics and the macroeconomy through the Geopolitical Risk (GPR) Index. The GPR is a news-based continuous measure of geopolitical threats and events, and their associated risks which quantifies the frequency of newspaper reports related to wars, terrorism, tensions among states and political actors, threatening the conduct of peaceful international relations. World War I and II, the Korean War initiation, the duration of the Cuban Missile Crisis, and the aftermath of 9/11 are well captured by the jumps in the GPR index. Furthermore, Caldara & Iacoviello (2022) also highlight the repercussions of a high GPR index values for the macroeconomic and firm-level environment.

The prevalence of uncertainty across economic decision-making was brought to the forefront owing to the Global Financial Crisis of 2007 – 2008. Geopolitical uncertainty, in addition to uncertainty about fiscal policies, monetary policies, tax, and regulations, have been highlighted as impactful towards economic and financial instability (Al-Thaqeb & Algharabali, 2019). In fact, such uncertainties were also identified to have contributed towards significant decline and slow recovery in economies across the US and Europe (FOMC, 2009; IMF, 2012)

The uncertainty levels surrounding economic policy decisions has been quantified by Baker et al. (2016) through their Economic Policy Uncertainty (EPU) Index, which is based on the frequency of specific terms related to the economy, policy, and uncertainty in newspapers. It reflects uncertainties about who will make economic policy decisions, what policies will be implemented, when they will occur, and the potential economic consequences of these actions. For example, for the US, the index spiked during 9/11, the Gulf Wars, and the Lehman Brothers bankruptcy. These events also appear in the development of the values of EPU index for the UK, in addition to the adoption of the Euro, and more recently, Brexit and the Conservative government crisis of October 2022.

Real economic activity and inflation might be affected by financial market variables. It is through financial markets that the real economy grows, whereby the flow of funds from savers to borrowers allows for investment in new capital, and the willingness of financial market agents to take on credit is highly dependent on the changes in the aggregate price level within the economy (Mishkin, 2019). Financial market variables possess information facilitating macroeconomic forecasts, owing to their forward-looking nature. The theoretical foundations of the forecasting content of financial market variables (asset prices, returns, interest rates etc.) for output and inflation have been researched based upon the Fisher effect, the term structure of interest rates and its expectations theory, monetary policy implications, and the time value of money-based valuation techniques applying discount factoring. Examples of these include the various variants of the dividend discount model and the discounted cash flow model. Furthermore, the informational role of financial market variables in forecasting the economy has been found to be significant by several empirical studies (e.g., Harvey, 1989; Stock & Watson, 2003).

With fears of recession overtaking several key global economies, and given the current, rather tense geopolitical environment, it is worth exploring how geopolitical risk measures, in tandem with financial market variables, perform in forecasting the future macroeconomy.

This thesis treats the study of Junttila & Vataja (2018) as its basis in terms of empirical design. However, in addition to the EPU index, the aim of this study is to utilize the information contained in the GPR index to forecast the macroeconomy, namely the economic activity and inflation, in Germany, the UK and the US. These three regions are chosen due to the size and influence of their economies and financial markets on the world. The US economy serves as a benchmark for global comparisons (Dees & Saint-Guilhem, 2011; Kose et al., 2003; Stock & Watson, 2005; Thimann, 2008); Germany also holds a strong position among the global economies and especially within the Euro area as evident from its role as the reference country during the convergence period for the monetary union, and its stability during the European debt crisis (Bartzsch et al., 2013; Bulmer, 2019; Bulmer & Paterson, 2010; McNamara & Jones, 1996). Furthermore, the UK economy has established a long-held global position and the impact of Brexit is testimony of that (Chang, 2018; Dhingra et al., 2018; Sentance et al., 2012). Building up thereon, the Germany and UK area-based study focus allows for a close vicinity to the Russo-Ukrainian conflict, therefore facilitating the information-containing role of financial market variables in terms of conveying more robust conflict-related effects and expectations (Federle et al., 2022).

Adhering to the guidance of Stock & Watson (2003), this thesis aims to facilitate the "intermittent and evolving nature" of the predictive relationships between financial market and macroeconomic variables by use of vector autoregression (VAR), Granger-causality tests, impulse response functions, and rolling out-of-sample forecasts.

1.2 Research Objectives

This research aims to explore the role of geopolitical risks and economic policy uncertainty in forecasting real economic activity and inflation, along with investigating the financial-macroeconomic linkages within Germany, which also stands to represent the overall euro-zone, the UK, and the US. It does so by formulating a VAR model for the period of January 1999 – December 2019 which treats the GPR index, the EPU index, 3-month money market interest rate, term spread, dividend yield, inflation, and real economic activity as endogenous variables, however ordered in an increasing level of endogeneity.

The following research questions outline the aims of this study:

1. What is the impact of the geopolitical risk index and the economic policy index on real economic activity and inflation in Germany, the UK, and the US; and how does it compare to the impact of conventional financial market variables?
2. How do the effects of geopolitical risks and economic policy uncertainty on real economic activity and inflation interact with each other?
3. Does the inclusion of the geopolitical risk index and economic policy uncertainty index improve the accuracy of real economic activity and inflation forecasts compared to using conventional financial market variables?

1.3 Research Methods

Entailed in the VAR method, Granger-causality tests identify the past values of which variables explain which current variable, and impulse response functions outline the dynamic response of a variable in response to a shock in another, thus providing insights to answer the first and second research questions.

The proportion of variance in the VAR model's predictions induced by an exogenous shock in the individual variables is quantified by forecast error variance decompositions, thus delving deeper into the second question, and paving the way for answering the third question.

Out-of-sample rolling forecasts of real economic activity and inflation based on conventional financial market variables versus models augmented with the EPU index, the GPR index, and both the EPU and GPR indices are then carried out and their respective forecast accuracy measures allow for the third research question to be answered. Such VAR-based rolling forecasts also attempt to capture time variation in the individual variables within the VAR system so to allow for any hidden dynamics among the variables missed in the previous steps to come to the forefront.

1.4 Structure of Thesis

This thesis is structured so to present a logical and coherent progression from the research problem to the justification of the methodology used, followed by a presentation of the results and their implications. The theoretical foundations of the topic are discussed in section 2, section 3 provides a literature review that builds upon the theory with empirical findings. The data is described in section 4, in addition to an explanation of the empirical methods applied. Section 5 presents the results obtained and their analysis, and section 6 discusses the empirical findings with regards to the research questions. The main conclusions are drawn in section 7.

2 THEORETICAL FRAMEWORK

The explanatory link between financial market variables and macroeconomic variables is well founded in theory.

Founding its basis in the quantity theory of money and the concept of money neutrality, the Fisher equation says that nominal interest rate equals real interest rate plus the expected inflation rate, thus effectively boiling down to changes in the expected inflation rate to be reflected in the changes in nominal interest rates (Fisher, 1930). Under the New Keynesian framework, the role of sticky prices and wages vis-à-vis the more flexible asset prices has also been highlighted such that the initial transmission of monetary shocks into the real economy can be represented by the flexible asset prices while sticky asset prices lag in adjusting to the new inflationary levels, followed by further transmission as the higher flexible asset prices encourage overall spending and economic activity (Goodhart & Hofmann, 2000).

The slope of the yield curve offers implications for monetary policy measures and signals investor expectations about future economic activity and inflation. Under expansionary measures with low short-term interest rates, the steeper the yield curve, the higher the expectations of economic upturns in the future. Under contractionary measure with high short-term interest rates, the flatter, even inverted, yield curve conveys expectations of future economic slowdowns. Interest rates being a channel of monetary policy and the positive relation between inflation and output growth is evident (Stock & Watson, 1989). Following the expectations theory of the term structure of interest rates, with the direction of the yield curve reflecting market participant's expectations of future inflation and interest rates, high expected inflation demands higher interest rates on long-term debt instruments as compensation (term premium), as seen by an upward slope of the yield curve, and vice-versa. Thus, the term spread finds theoretical backing for containing predictive information for both future inflation and real economic activity (Browne & Paolo Manasse, 1990).

Considering the equity market-side, many capital asset pricing models connect stock prices with the macroeconomy, especially the macroeconomic risks. Most notably, the arbitrage pricing theory which relates expected returns to macroeconomic variables constituting systematic risk (Ross, 1976); as well as the consumption capital asset pricing models whereby expected stock returns are dependent on states of the macroeconomy which then affect consumption preferences over time (Breeden, 1979; Merton, 1973).

In fundamental stock valuation, the concepts of the discount factor and that the expected future value of earnings reflect today's fair value of the stock, e.g., the Gordon growth model or other such variants of the dividend discount model, or the discounted cash flow model, further reflect the future informational content of the stock market (Gordon, 1962). Rather intuitively, the stronger the economy, the higher the expectations of future earnings/cash flows, and the higher the current stock price.

3 LITERATURE REVIEW

Forecasting real economic activity and inflation is no easy task, even with the information conveyed by financial and macroeconomic variables. Due to the multidimensional and dynamic environment of the macroeconomy, there are limited stylized facts common to multiple economies. Despite this limitation, a relevant common observation has been the stronger and more significant forecasting content of financial market variables for real economic activity than for inflation, with out-of-sample forecasts of real economic activity modelled from asset prices being exhibiting more stability and reliability over those of inflation (e.g., Estrella et al., 2003; Stock & Watson, 2003).

Constituting the foundational literature on the role of asset prices for macroeconomic forecasts, Stock & Watson (2003) conclude more complexities involved in models comprising of financial market variables than simplicity. While it is established that certain asset prices possess strong and statistically significant marginal predictive content for output more than for inflation, which asset prices, when, and where, demands case-by-case inference. Nonetheless, the variables highlighted by Stock & Watson (2003) include the short-term interest rate, interest rate spreads, stock prices and returns, and housing prices, among others.

Going further, Stock & Watson (2003) describe the instability in the relationships between financial market variables and macro variables as "the norm". Moreover, the reliability of a predictor in giving stable forecasts isn't guaranteed by in-sample significance tests. However, a solution to the instability problem is posited such that combining the information provided by individual predictors largely sidesteps the instability, at least for output growth, while the case of inflation lacks universality in its results. Forni et al. (2003) extend support to this solution in the inflation context as well with multivariate inflation forecasts being observed to outperform their univariate counterparts at one-, three-, six-, and 12-month horizons. Multivariate real economic activity forecasts were however found to be limited to one- and three-month horizons. More recently, the aggregation of different forecasts to achieve higher accuracy has become a stylized fact (Petropoulos et al., 2022).

Additionally, the issue of co-movements also comes to the forefront when considering financial market variables. According to Mumtaz et al. (2011), the significance of regional co-movements of real variables has increased in explaining domestic output growth, given that the significance of global co-movements has decreased. Additionally, the opposite was found to hold for inflation as changes in a global inflation factor have well-explained changes in domestic inflation since 1985. Furthermore, Kabukçuoğlu & Martínez-García (2018) posit that the inclusion of cross-country interactions results in domestic inflation forecasts of increased accuracy for Germany, the UK, and the US, among others.

Thus, it can be argued that not only do multivariate models tackle unstable forecasts, but with the appropriate variables, also account for co-movements across different regions and encompass the increasing interdependencies that come with increasing globalization. In this research, this particular aspect has been attempted to be covered by using the global GPR and EPU indices, instead of the country-specific indices, while using country-specific financial market variables.

In his pioneering work, Harvey (1989) establishes the upper edge of credit markets in accurately forecasting the real economy. While acknowledging the sound theoretical foundations and strong empirical support for the predictive content of the short-term interest rate for output and inflation, Stock & Watson (2003) do also report its limited marginal predictive content for the output once the term spread has been accounted for. On the contrary, Ang et al. (2006) assert the dominance of the short-term interest rate over any term spread when it comes to explaining future GDP growth. Support for Ang et al. (2006) is extended by Loizides & Vamvoukas (2010) in the context of developing economies whereby short-term interest rates were found to have significant predictive content for real economic activity. For a developed, small open economy in the euro-area like Finland, Kuosmanen & Vataja (2014) also find the short-term interest rate to be a competent GDP growth predictor, in addition to lags of GDP growth itself, given that the economic conditions are stable. During crisis periods, the term spread is preferred, in addition to stock returns.

Owing to its role as a monetary policy tool, the impacts of the short-term interest rate on inflation are well-studied. Under efficient markets, future inflation rate expectations were found to be appropriately reflected in the current short-term interest rates by Fama (1975). Under inefficient markets too, short-term interest rates, should they be appropriately, i.e., aggressively placed by central banks, can communicate the correct information, and reflect correct forecasts of future inflation rates (Anufriev et al., 2013). According to Goodhart & Hofmann (2000), future inflation is well-indicated by financial market variables, specifically the short-term interest rate, house price inflation, and broad money growth, at a two-year horizon, whereas limited forecasting content was suggested to be possessed by equity prices.

Thus, it can be inferred that the short-term interest rate offers information for future real economic activity and inflation given that the economic conditions at the time of forecasting are accounted for, and the information communicated by monetary authorities is reflective of the true dynamics in order for market participants to gauge the correct predictions.

The role of the monetary authority and its communication is also highlighted by the rational expectations model presented by Estrella (2005) to explain why the term spread, or the slope of the yield curve, entails forecasting content for inflation and output. The term spread and the information it conveyed about future inflation and output was found to be a function of the monetary policy rule and was found to improve in conjunction with other relevant variables.

The direct relationship between the term spread and real economic activity has been frequently highlighted. The well-observed indication of a recession in the form of an inverted yield curve offers succinct justification for such. Estrella & Mishkin (1998) indicate that while the out-of-sample performance of stock prices were viable for business cycle downturns between one-to-three quarter horizons, those of the term spread were significant for longer, from one to eight quarters ahead. More recently, Kuosmanen & Vataja (2017) find the term spread to generally have the highest Shapley values, i.e., the highest percentage contribution to the goodness-of-fit of a model also containing real stock returns and real short-term interest. In their overall conclusion, the forecasting performance for real economic activity is improved over and above the AR benchmark with the inclusion of the term spread, stock returns, and the real short-term interest rate for the G-7 countries.

The term spread emerges as a well-researched variable for its predictive content in the case of inflation as well. The nominal term spread is found to have significant information about future inflation at longer maturities, specifically starting at six months and above (Mishkin, 1990b, 1990a). Some significant informational content for future inflation is also found in the short-term term spreads for Germany and the UK by Mishkin (1991). Estrella & Mishkin (1997) find the term spread to be a strong and significant predictor of future inflation (and future real activity) after controlling for the lagged inflation (and real activity) for both the US and Europe, while highlighting the importance of long forecasting horizons. Lee (2015) highlights the importance of successful inflation targeting in ensuring the predictive content of the term spread for future inflation However, the results of Lee (2015) also indicate that the inclusion of the short-term interest rate weakens the term spread as a predictor.

While the term spread holds well for real economic activity forecasts, its inability to outperform AR models based on lags of inflation itself is the usual outcome when forecasting inflation (Plakandaras et al., 2017; Stock & Watson, 2003). Additionally, Plakandaras et al. (2017) find that nonlinear models employing the term spread also fail to outperform autoregressive models for forecasts of future US inflation.

It can thus be argued that for forecasting real economic activity and inflation, the term spread has been of significance. However, there are mixed results on whether its conjunction with especially the short-term interest rate improve or deteriorate this significance for inflation. Forecasting inflation in itself emerges as a complicated task. Furthermore, the dependence on monetary authorities and their policies extends to the term spread as well, in addition to the previously discussed short rate.

Regarding the predictive interactions between the credit and equity markets for the economy, Chionis et al. (2010) posit that a forecasting model augmented with the composite European stock index after the yield curve improves upon forecasts of real economic activity. Gogas & Pragidis (2012) offer further support as they find significant forecasting content for the real economic activity of eight EU countries, including Germany and the UK, in a model containing the respective term spreads, stock indices, and unemployment rates. For forecasting inflation on the other hand, literature indicates that equity prices, along with housing prices, extract monetary policy information, (Goodhart & Hofmann, 2000; Stock & Watson, 2003), with Tkacz & Wilkins (2008) finding stock and housing prices to improve upon inflation forecasts.

Overall, the role of stock market information, particularly that of dividend yield, as a predictive variable for both real economic activity and inflation has been gaining ground in literature. Chen (1991), in their exploration on the forecasting ability of the dividend yield, find proof that the above average values of dividend yield are able to forecast a below average output growth up until a 2-quarters-ahead horizon. Andreou et al. (2000) emphasize the role of dividend yields over that of stock returns in the UK, while establishing the leading indicator role for the term structure for real economic activity across the UK, the US and Germany. Black et al. (2015) identify a long-run relationship among stock prices, dividends, output, and consumption across 29 international markets, while also finding forecasting content in a joint stock market-macro vector for future stock returns and future consumption growth, an indicator of economic activity. The 29 international markets were of various sizes ranging from European economies to the US, Asia, Australia, and New Zealand.

A study by Junttila (2002) on the predictive content of economic tracking portfolios essentially serving as pooled informational variables of the underlying future real activity or inflation that finds significant support for the predictive role of financial markets for the macroeconomy within the eurozone, particularly for Germany, Italy and France, and the US. Furthermore, the role of the term spread, and dividend yield is highlighted considering their correlations with future consumer price index and industrial production. Highly positive correlation is found between the past values of the dividend yield and future inflation, whereas this correlation is mostly negative in the case of future economic activity; and the lags of term spread exhibit negative correlations with future inflation and positive with future real activity. Binswanger (2000) offer support through his finding of significant negative correlations between the dividend yield and future GDP and future industrial production and highlight the predictive role of the dividend yield for future real economic activity for the U.S. The role of the stock market dividend yield, in addition to the short-term interest rate, is further emphasized by Junttila & Korhonen (2011) as its informational content for future output growth and inflation is highlighted especially in times of financial and economic distress for the UK, euro-area, Japan, and the US.

The financial-macroeconomic linkage is a dynamic one, characterized by the time-variation, structural changes, and exogenous shocks. Serfling & Miljkovic (2011) shed light on some of these dynamics as they point out the explanatory power of lagged interest rates, stock returns, and the industrial production index for the current industrial production index, and that of lagged dividend yield, interest rates, stock returns, money supply, and the consumer price index for current consumer price index, among others for the US. More recently, Agiakloglou et al. (2016) highlight similar dynamic causal relationships for the EU through Granger-causality tests, e.g., changes in oil prices causing inflation, inflation causing interest rates, and changes in oil prices causing interest rates, in addition to market returns causing interest rates, interest rates causing changes in GDP, and market returns causing changes in GDP.

As previously mentioned, Kuosmanen & Vataja (2014) confirm the forecasting ability of the short rate and the term spread for economic growth. Additionally, they also highlight the condition of the overall economy at the time of forecasting by concluding that for Finland, and other euro-area small open economies, the short-term interest rate is a competent GDP growth predictor, in addition to lags of GDP growth itself, during periods of economic steadiness, whereas the term spread is preferred, in addition to stock returns, during crisis periods. Kuosmanen & Vataja (2017) describe the 2008 global financial crisis as a "watershed event" whereby financial market variables are proven to improve out-of-sample forecasts for real economic activity rather well during and after the crisis, thus re-establishing financial variables' knack for forecasting real economic activity after having been seemingly lost since the mid-1980s. The evidence of structural breaks found in Junttila & Vataja (2018) also suggests that the 2008 global financial crisis possessed some characteristics that structurally changed the predictive relationships between the explanatory financial variables and the macroeconomy as they conclude the outperformance of yield curve and excess stock returns-based forecasts of real output over an AR-benchmark and an augmented model containing economic policy uncertainty during and after the 2008 financial crisis.

Another key aspect that has stood out from the discussion so far is that of overall information, particularly, the communication of information. Information, whether limited solely to financial and/or macroeconomic variables, or added on by other, more exogenous sources, has strong bearings on the outlook for the overall economy, thus justifying the increase in research done on the reaction of the financial and macroeconomic variables to communication and the news (e.g., (Duffee, 2022; Gotthelf & Uhl, 2018; Larsen et al., 2021; Lukauskas et al., 2022; Stotz, 2019)). At the forefront of such news is that of geopolitical risks and economic policy uncertainty.

Caldara & Iacoviello (2022) explore the effects of geopolitical risks on the US macroeconomy using VAR models-based models for 1985-2019 whereby geopolitical shocks (threat and realization) result in declining real activity due to long-term reductions in investment, employment, and stock prices. Furthermore, rises in the GPR index are related to rises in the probability of economic crises; falls in GDP growth; and rises in downside risks associated with GDP growth. Balli et al. (2022) confirm the transmission of geopolitical risks across countries with bilateral trade and geographical proximity being key factors of such. As per Jalkh & Bouri (2022), the global GPR index exhibits a negative long-run relationship with US Treasuries' returns and a positive long-run relationship with US Treasuries' volatilities. According to Lee (2019), co-movements between 37 global stock market indices and the GPR index are consistent over June 1997-December 2017. Furthermore, Pehlivanoğlu et al. (2021) find the GPR index to be causal to consumer and producer confidence within emerging economies. Key insight is provided by Umar et al. (2023) on the information conveyed by the GPR index to key financial market variables. Specifically in context of Russia's war on Ukraine, they find the Russian stock market and crude oil prices respond oppositely to the GPR index, and that the impact of the GPR index realizes itself in the medium-to-long term with higher risk in financial markets. Overall, Umar et al. (2023) underline financial markets' efficiency in communicating geopolitical information.

Regarding economic policy uncertainty, Baker et al. (2016) reveal the EPU index to explain significant variation in stock price volatilities, investment rates and employment growth. As per their VAR analysis, increases in the EPU index indicated a negative impact on economic activity in the US and Europe. The transmission of risks founded in the respective sovereign spreads of major euro-zone countries has been found to be aggravated by increases in their respective EPU indices by Bernal et al. (2016). Transmission between the US EPU index and the European macroeconomy is emphasized by Colombo (2013) as a significant negative relationship is identified between US EPU index spikes and European economic activity and prices indices with the impact of US EPU index in fact trumping that of euro-area EPU spikes on said variables. A significant negative relationship has also been identified between the EPU index and financial stability in Germany, the UK, and the US, in addition to 20 other global economies Phan et al. (2021). While extending support for the transmission of the effects of EPU across countries, Ozili (2021) also bring forth significant EPU correlations across the EU, overall Europe, and the Americas during the global financial crisis. In their research on the forecasting ability of the EPU index for real economic activityJunttila & Vataja (2018) find forecasts to improve once augmented with the lagged EPU index in addition to lags of the industrial production index, term spread, short-term interest rate, and excess stock returns for the US, UK, and euro-area, especially prior to the 2008 global financial crisis.

Connecting the dynamics of the GPR and EPU indices to explore financial-macroeconomic linkages within Europe, Stolbov & Shchepeleva (2021) find no significant impacts of the GPR index on the economic growth, however, the EPU index emerges as notable in its contractionary impact on the economy. Similar results are found for forecasting US GNP growth by Segnon et al. (2018) as they find the inclusion of the EPU index in addition to US GNP itself to yield relatively more accurate forecasts than simple univariate forecasts. Furthermore, they also find the EPU index to possess forecasting content over that of the GPR index and the VIX for US recession forecasts. Overall, Segnon et al. (2018) establish the EPU index on par with the term spread in terms of forecasting content for output.

The interactions between the two indices and inflation are lesser explored. Adeosun et al. (2022) posit the EPU index and the GPR index as "primary factors driving inflation" across the US, Canada, the UK, Japan, and China. Furthermore, Adeosun et al. (2022) also study the interaction between the EPU and GPR indices on inflation through a single variable, finding the combined impacts of the two indices to exhibit causality with inflation, unidirectional and bidirectional depending on the country in question. Considering the individual roles of the two indices in forecasting inflation, Su et al. (2020) suggest the GPR index to possess forecasting content for Venezuelan inflation by way of oil prices especially in periods of increased geopolitical risks, and Balcilar et al. (2017) provide evidence for more accurate US inflation forecasts after accounting for the EPU index in addition to US inflation itself relative to conventional forecasting models.

Overall, it is evident that the EPU index and the GPR index can have key roles to play within financial and macroeconomic dynamics. Additionally, evidence is also found, albeit limited, supporting their dynamics of inflation. Thus, the two indices can be posited to be potent potential predictors of real economic activity and inflation, given appropriate models and model specifications.

A summary of the most important empirical studies and their results can be found in Table 1 below.

Table 1. Foundational literature and key findings

Study	Data	Methodology	Key Findings
Stock & Watson (2003)	Forecasting real economic activity and inflation	In sample and out-of-sample forecasts	Real economic activity is better forecasted by asset prices than inflation. Asset prices with significant predictive content are the short-term interest rate, interest rate spreads, stock prices and returns, and housing prices, among others. Asset prices-based macroeconomic forecasts are prone to instabilities. Aggregating the information found in individual predictors can potentially fix the instability.
Estrella (2005)	Annual, 1963 - 2002	VAR	The term spread possess forecasting content for real economic activity and inflation. These term spread-based forecasts are improved when modelled with other relevant variables.
Junttila & Korhonen (2011)	Monthly, UK & Japan: 09/1978 – 01/2007, Euro-area: 01/1979 – 01/2007	Linear forecast modelling	Dividend yield and the short-term interest rate are significant predictors of real economic activity and inflation especially during crisis periods across the UK, euro-area, Japan, and the US.
Serfling & Miljkovic (2011)	Monthly, 01/1959 – 12/2009	VECM	Current IPI is explained by lags of interest rates, stock returns, and the IPI itself, and current CPI is explained by lags of dividend yield, interest rates, stock returns, money supply, and the CPI itself.
Colombo (2013)	Monthly, 01/1999 – 06/2008	Structural VAR	Increases in the US EPU index yield significant negative responses in euro-area economic activity and price indices, with their respective variances comprising of a higher proportion of shocks from the US EPU index than the European EPU index.
Kuosmanen & Vataja (2014)	Quarterly, 01/1988 – 02/2011	h-step ahead forecasts (h = 1, 2, and 4 quarters)	For small euro-area economies, the short-term is a leading predictor of GDP growth during stable economic conditions, whereas during crises, the term spread is preferred.

Black et al. (2015)	Quarterly, 01/1973 – 12/2010	Cointegration analysis and rolling forecast regression	Cointegration exists in the long run among stock prices, dividend yield, output, and consumption across 29 international markets. A vector conveying stock market and macroeconomic information contains significant forecasting power for future consumption growth and stock returns.
Agiakloglou et al. (2016)	Quarterly, 01/2000 – 12/2012	VAR, granger causality, and impulse response functions	In the EU, causal relationships are found among inflation, real economic activity, the short-term interest rate, and oil prices.
Baker et al. (2016)	Monthly, 01/1985 – 12/2014	Panel VAR	Increases in the EPU index have a negative impact on economic activity in the US and Europe.
Bernal et al. (2016)	Quarterly, 10/2008 – 04/2013	Two-step estimation of change in value-at-risk	For Germany, France, Italy, and Spain, increases in the EPU index worsen the shock transmission across the countries through their sovereign bonds.
Kuosmanen & Vataja (2017)	Quarterly, 01/1980 – 12/2014	h-step ahead forecasts (h = four quarters)	For the G-7 countries, real economic activity forecasts including the term spread, stock returns, and the real short-term interest rate outperforms the AR benchmark, especially during and since the 2008 global financial crisis.
Kabukçuoğlu & Martínez-García (2018)	Quarterly, 01/1984 – 01/2015	h-step ahead forecasting models (h = 1, …, 12 quarters)	Interaction terms between countries improve inflation forecasts for Germany, the UK, and the US, among others.
Junttila & Vataja (2018)	Monthly, 01/1997 – 09/2016	AR forecast modelling	Lags of the EPU index provide more accurate forecasts of real economic activity when added to a model with the lags of the industrial production index, term spread, short-term interest rate, and excess stock returns for the US, UK, and euro-area, however before the 2008 global financial crisis. During and after the crisis, the term spread, and excess stock returns are better predictors.
Lee (2019)	Monthly, 06/1997 – 12/2017	Copula probability modelling	Stock indices of 37 global markets co-move with the global GPR index.
Phan et al. (2021)	Annual, 1996 - 2016	OLS regression	For Germany, the UK, and the US, among others, there is a significant negative relationship between their respective EPU indices and financial stability.
Caldara & Iacoviello (2022)	Quarterly, 01/1986 – 12/2019	VAR	For the US, rising geopolitical risks result in decreases in real economic activity, and increases in economic crisis probabilities.

4 DATA AND METHODOLOGY

4.1 Data Description

Time series data of monthly frequency has been retrieved from the OECD database, for all financial and macroeconomic variables except the aggregate dividend yield, which has been retrieved from Refinitiv as it was unavailable on the OECD database. The economic policy uncertainty index data has been retrieved from the "policyuncertainty.com" database curated by Baker et al. (2012)[1] and the geopolitical risk index data has been retrieved from "matteoiacoviello.com", a webpage maintained by (Wells et al., 2020)[2]. Following are the specific time series variables used:

- Global geopolitical risk index (*GPR,* source: matteoiacoviello.com)
- Global economic policy uncertainty (*EPU,* source: policyuncertainty.com)
- Term spread (*TS*), calculated by differencing the 10-year money market interest rate and the 3-month market interest rate (source: OECD)
- Dividend yield (*DY,* source: Refinitiv)
- 3-month, money market interest rate (*i3.* source: OECD)
- Inflation (*INF*), calculated as the annual change in the log values of the consumer price index (source: OECD)
- Real economic activity (*REA*), calculated as the annual change in the log values of the industrial production index (source: OECD)

The choice for using global-level indices (GPR and EPU) is backed by the definitions of the indices. As both are news-based indices, it is safe to assume that domestic-level indices may be more impactful on the economic conditions of their respective countries, however, possibly at the cost of global implications, comparability, and coherence. Having the indices reflect global events rather than domestic events would accommodate the increasing interconnectedness of major economies. Additionally, more comparability across countries would be provided by results based on the standardized global indices over country-specific indices, thus allowing for more coherent conclusions to be drawn on the otherwise irregular and dynamic relationships between financial and macroeconomic variables.

For the sake of readability, each variable has been abbreviated, mainly in tables and figures, in accordance with the country it represents, e.g., real economic activity is represented by *GERREA* for Germany, for UK it is *UKREA,* and

[1] Link to global economic policy uncertainty index data: https://www.policyuncertainty.com/global_monthly.html
[2] Link to global geopolitical risk index data: https://www.matteoiacoviello.com/gpr.htm

USREA for the US. Furthermore, in cases where the lag-one difference of a variable has been taken to tackle a unit root, the letter "D" has been added in front, e.g., lag-one difference of inflation in the UK is written as *DUKINF*. Additionally, the shortened "*logGPR*" and "*logEPU*" are used to represent the log values of the global geopolitical risk index and the global economic policy index, respectively.

Descriptive Plots and Statistics

This section discusses the descriptive properties of all the variables in consideration, beginning with the dependent variables of the studies, i.e., real economic activity and inflation, followed by the remaining five explanatory variables of the indices and financial market variables across the sample period of January 1999 – December 2019. The chosen sample period circumvents the financial and economic disruptions caused by COVID-19, and later Russia's invasion of Ukraine. The results obtained based on this sample period would be more reflective of the historical patterns through various economic conditions and geopolitical events, thus establishing a baseline of the dynamic relationships among the variables.

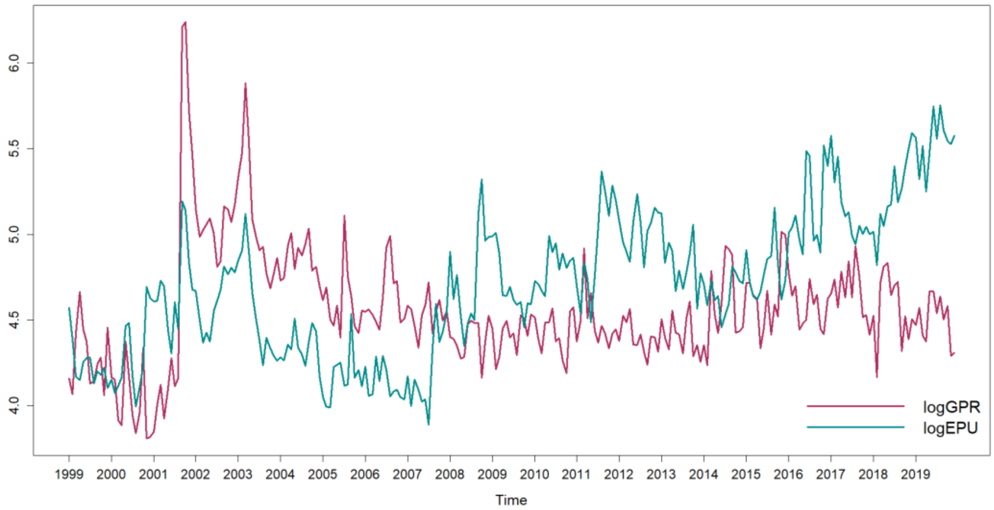


Figure 1. Log of the global GPR index (*logGPR)* and global EPU index (*logEPU)*.

As seen from Figure 1, there is only one event where the two indices exhibit explicit co-movement: in the after-effects of 9/11, up until the onset of the Global Financial Crisis around mid-2007 where *logEPU* surpasses *logGPR*. This is consistent with the correlation of 0.07 presented in Table 3. The difference in behaviour of the two indices is hence evident.

Vis-à-vis *logGPR* and *logEPU*, Figure 2 and Figure 3, plot the German real economic activity and German inflation, respectively; Figure 5 and Figure 6 plot UK real economic activity and UK inflation, respectively; and Figure 8 and Figure 9 plot US real economic activity and US inflation, respectively. The macro and financial variables of Germany are seen in Figure 4; of the UK in Figure 7; and of the US in Figure 10. As described earlier, the inflation rate has been calculated as the annual change in the log values of the consumer price index, and real economic activity has been calculated as the annual change in the log values of the industrial production index.

Overall, falls in real economic activity across the three countries tend to coincide with spikes in especially *logEPU*, indicating opposite movements between real economic activity and economic policy uncertainty. Interestingly for inflation, co-movements can be observed with *logEPU* for all three countries, especially around the Global Financial Crisis, and then again around 2011 – 2017, which can be characterized as the Crisis recovery period. Outside of these periods, somewhat opposite movements can be seen. The movements of the macro variables with *logGPR* appear more unclear.

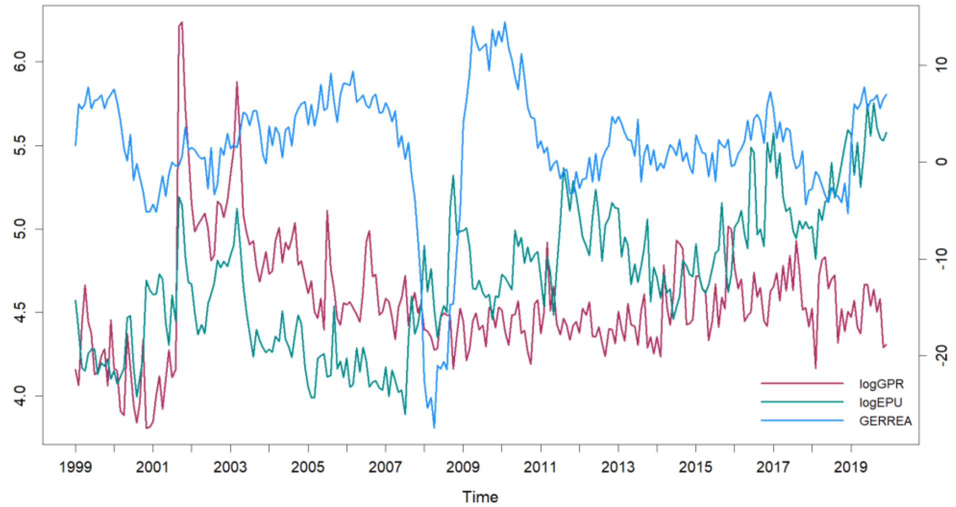


Figure 2. Log global GPR index (*logGPR*, left scale), log global EPU index (*logEPU*, left scale), and German real economic activity (GERREA, right scale).

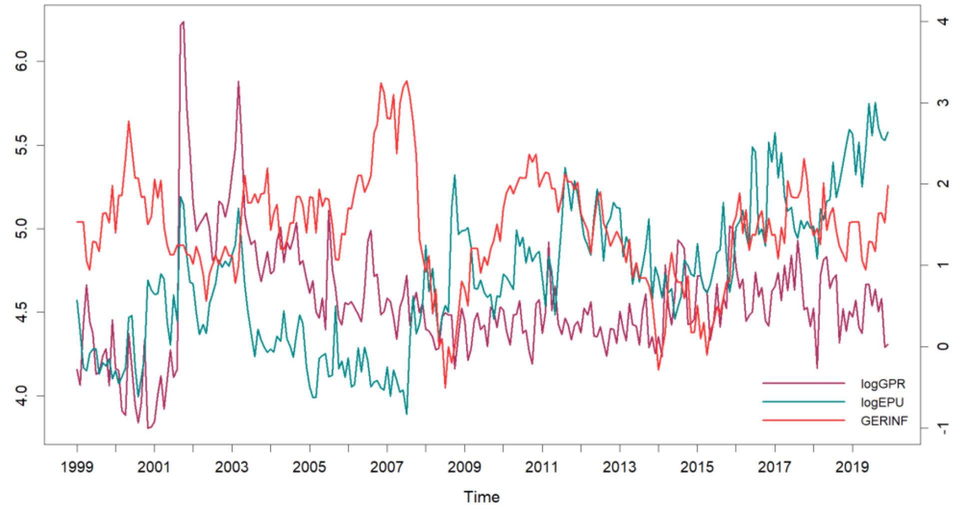


Figure 3. Log global GPR index (*logGPR*, left scale), log global EPU index (*logEPU*, left scale), and German inflation (*GERINF*, right scale).

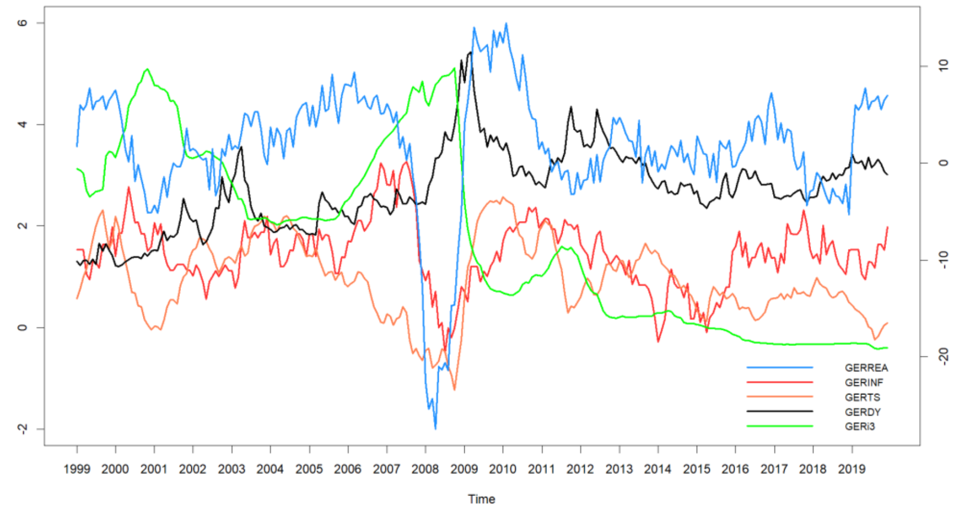


Figure 4. Germany macroeconomic and financial variables: real economic activity (*GERREA*, right scale), inflation (*GERINF*, left scale), term spread (*GERTS*, left scale), dividend yield (*GERDY*, left scale), and 3-month money market interest rate (*GERi3*, left scale).

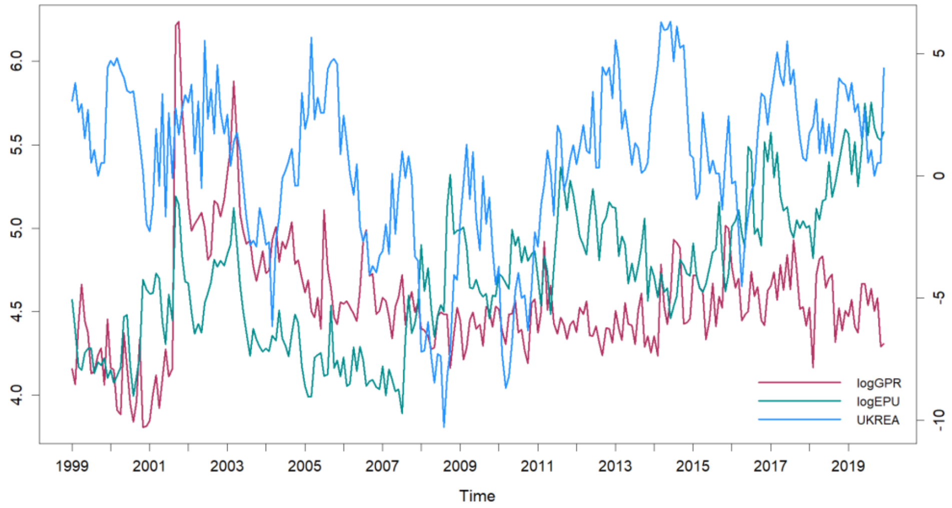


Figure 5. Log global GPR index (*logGPR*, left scale), log global EPU index (*logEPU*, left scale), and UK real economic activity (UKREA, right scale)

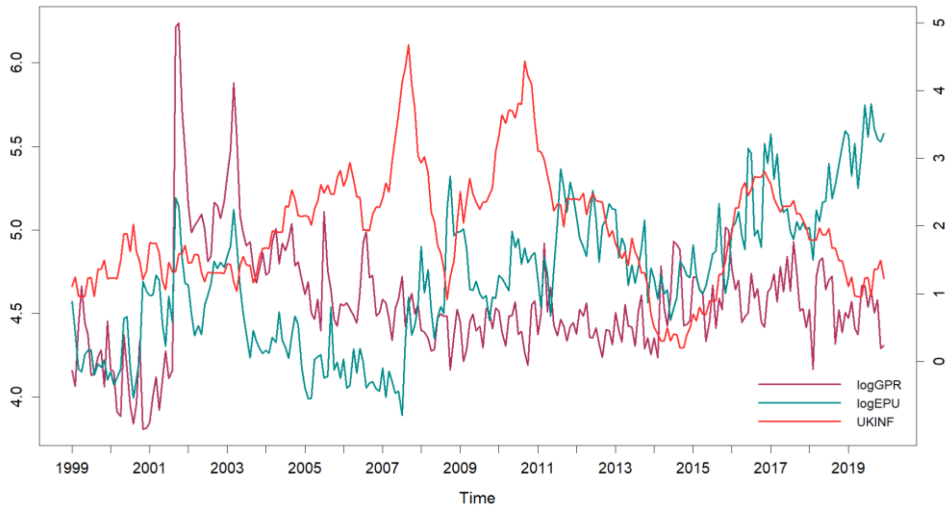


Figure 6. Log global GPR index (*logGPR*, left scale), log global EPU index (*logEPU*, left scale), and UK inflation (*UKINF*, right scale)

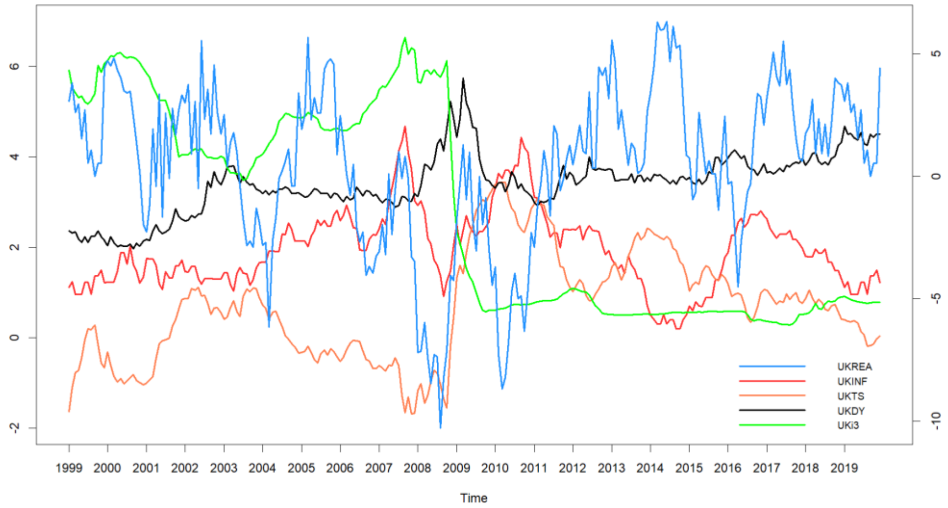


Figure 7. UK macroeconomic and financial variables: real economic activity (*UKREA*, right scale), inflation (*UKINF*, left scale), term spread (*UKTS*, left scale), dividend yield (*UKDY*, left scale), and 3-month money market interest rate (*UKi3*, left scale)

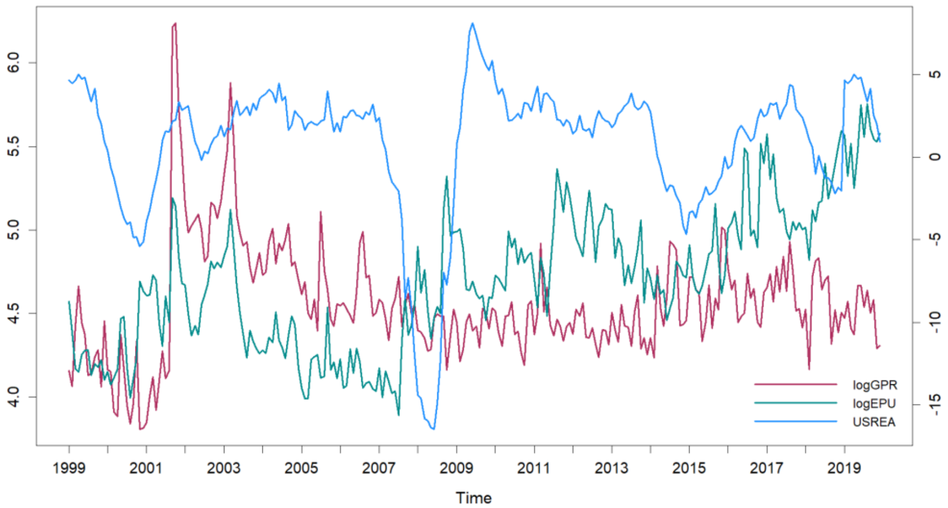


Figure 8. Log global GPR index (*logGPR*, left scale*)*, log global EPU index (*logEPU*, left scale*)*, and US real economic activity (USREA, right scale)

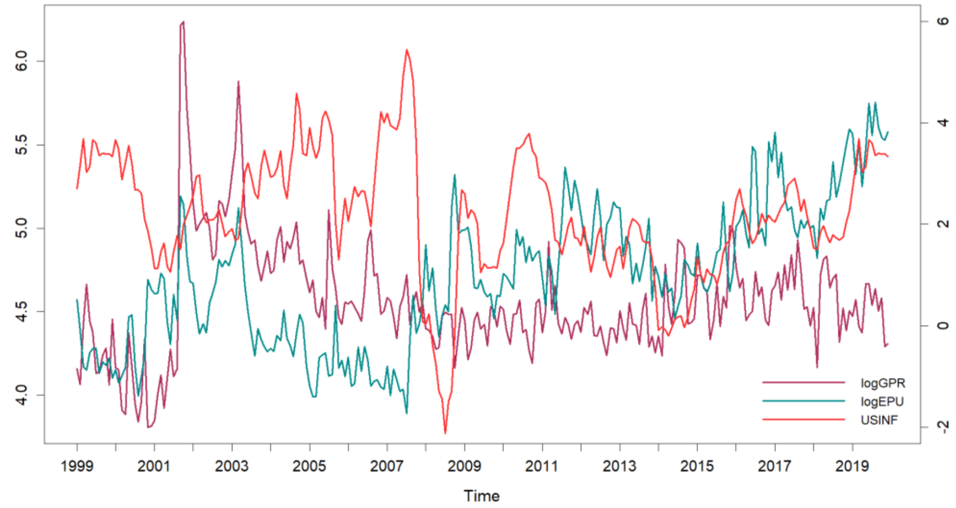


Figure 9. Log global GPR index (*logGPR*, left scale), log global EPU index (*logEPU*, left scale), and US inflation (USINF, right scale).

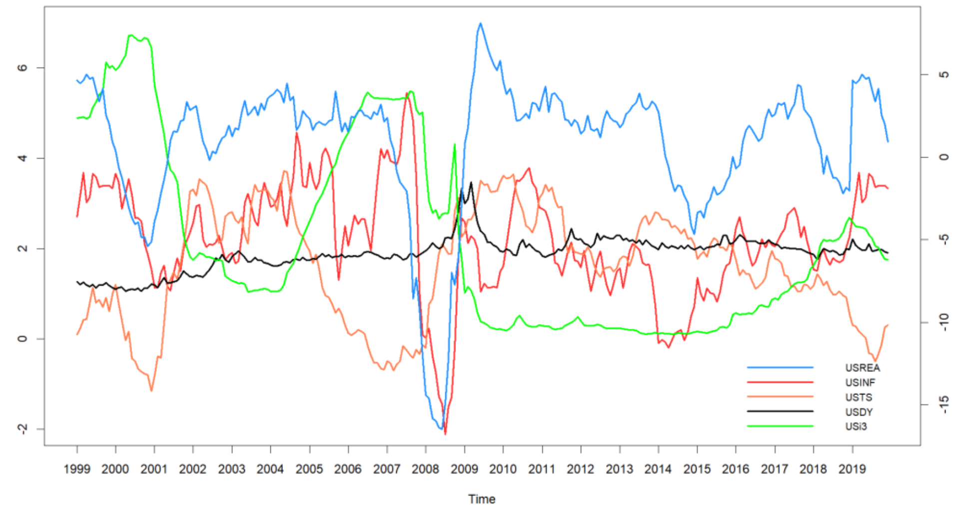


Figure 10.US macroeconomic and financial variables: real economic activity, (*USREA*, right scale), inflation (*USINF*, left scale), term spread (*USTS*, left scale), dividend yield (*USDY*, left scale), and 3-month money market interest rate (*USi3*, left scale).

Descriptive statistics and unit root test results are then presented in Table 2 and the correlation coefficients (Pearson’s R) are shown in Table 3.

Table 2. Descriptive statistics and unit root tests

Panel A: Germany										
	Min	**Mean**	**Max**	**StDev**	**StErr**	**Skew**	**Kurt**	**ADF**	**PP**	**KPSS**	**ZA**
REA	-27.48	1.71	14.5	6.39	0.40	-1.79	8.67	-2.53	-3.58***	0.03	-4.00 (2007-04)
INF	-0.5	1.45	3.27	0.67	0.04	-0.05	3.59	-3.04**	-3.83***	0.16	-3.87 (2012-07)
logGPR	-0.91	0	1.79	0.41	0.03	1.39	6.69	-5.67***	-7.51***	0.28	-4.03 (2001-08)
logEPU	3.35	4.8	6.12	0.47	0.03	-0.13	2.91	-5.15***	-8.25***	1.12***	-3.96 (2003-05)
TS	-1.23	0.95	2.58	0.78	0.05	-0.05	2.63	-3.05**	-2.83*	0.23	-5.31** (2008-10)
DY	1.20	2.71	5.43	0.79	0.05	0.40	3.62	-2.59*	-2.47	0.79***	-4.34 (2008-01)
i3	-0.42	1.75	5.11	1.75	0.11	0.36	1.81	-1.32	-1.25	1.28***	-4.86** (2008-10)

Panel B: The UK											
	Min	**Mean**	**Max**	**Stdev**	**StErr**	**Skew**	**Kurt**	**ADF**	**PP**	**KPSS**	**ZA**
REA	-10.28	0.50	6.32	3.29	0.21	-0.78	3.40	-3.02**	-4.19***	0.25	-3.8 (2011-10)
INF	0.20	1.94	4.68	0.85	0.05	0.55	3.42	-2.32	-2.55	0.2	-3.37 (2011-11)
logGPR	-0.2	0.77	2.58	0.39	0.02	1.13	6.58	-4.80***	-5.60***	0.11	-4.23 (2001-08)
logEPU	3.18	4.66	6.33	0.54	0.03	-0.06	2.9	-3.43**	-5.04***	0.99	-3.48 (2003-04)
TS	-1.68	0.68	3.45	1.19	0.08	0.28	2.51	-2.27	-2.64*	0.50**	-6.86*** (2008-10)
DY	1.97	3.40	5.75	0.67	0.04	0.03	3.49	-1.99	-2.05	1.01***	-4.43 (2009-07)
i3	0.28	2.76	6.65	2.26	0.14	0.26	1.32	-1.19	-1.45	1.32***	-8.70*** (2008-10)

Panel C: The US											
	Min	**Mean**	**Max**	**Stdev**	**StErr**	**Skew**	**Kurt**	**ADF**	**PP**	**KPSS**	**ZA**
REA	-16.49	0.84	8.16	4.16	0.26	-2.09	8.39	-2.62*	-3.26**	0.05	-3.31 (2009-10)
INF	-2.12	2.20	5.45	1.22	0.08	-0.46	3.79	-4.39***	-2.97**	0.31	-3.89 (2007-09)
logGPR	-2.44	-1.13	0.47	0.51	0.03	0.21	3.16	-5.50***	-8.38***	0.34	-3.42 (2006-09)
logEPU	3.9	4.58	5.61	0.29	0.02	0.51	3.5	-5.89***	-7.35***	0.09	-3.8 (2014-08)
TS	-1.16	1.60	3.72	1.23	0.08	-0.26	2.09	-2.19	-2.47	0.12	-3.63 (2000-12)
DY	1.05	1.89	3.47	0.38	0.02	0.15	5.12	-2.55	-2.33	0.96***	-3.4 (2002-04)
i3	0.11	2.14	6.73	2.01	0.13	0.81	2.31	-1.67	-1.93	0.72**	-5.30** (2008-10)

Panel D: logGPR and logEPU											
	Min	**Mean**	**Max**	**Stdev**	**StErr**	**Skew**	**Kurt**	**ADF**	**PP**	**KPSS**	**ZA**
logGPR	3.81	4.56	6.24	0.34	0.02	1.36	7.62	-5.16***	-5.91***	0.11	-4.62* (2001-08)
logEPU	3.89	4.71	5.75	0.42	0.03	0.26	2.38	-2.64*	-2.86*	1.17***	-3.95 (2003-04)

Notes: Table 2 presents descriptive statistics and unit root test results for Germany (Panel A), the UK (Panel B), and the US (Panel C), as well as for *logGPR* and *logEPU* (Panel D). The unit root tests conducted were the Augmented Dicky-Fuller (ADF) test, the Phillips-Perron (PP) test, and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test and the Zivot-Andrews (ZA) test was used to identify unit roots with structural breaks. Structural break dates are presented in brackets. The asterisks indicate significance levels with * representing the 10% level, ** representing the 5% level, and *** representing the 1% level.

Stationarity is indicated for *logGPR* by all unit root tests, with the ZA test identifying a potential break point in August 2001 at the 10% level. Hence, log-levels are inferred to be appropriate for the GPR index, as represented by *logGPR*.

For *logEPU*, the ADF and PP test results give some evidence for stationarity at the 10% level, however, the KPSS test result gives rather significant evidence of non-stationarity with a unit root at the 1% level. According to the ZA test, *logEPU* has no significant structural break in series. Considering that the EPU index utilizes a text-based approach to quantify keywords on the uncertainty surrounding economic policy in major newspapers, differencing the series can lead to important information being lost. Thus, this study pursues EPU index in log-levels, i.e., *logEPU*.

Justification for using *logGPR* and *logEPU* in levels is not limited to unit root tests but also extends to the nature of the variables and the context of this research. Since the levels of the two indices represent geopolitical risks and economic policy uncertainty at a given point in time throughout the sample period, it is argued that their usage is appropriate to reflect the forecasting content of geopolitical risks and economic policy uncertainty for inflation and real economic activity and can capture possible long-term dynamics among the variables especially considering the large sample period. Furthermore, it can be argued that within the VAR analysis when lagged values are accounted for, the short-term dynamics would also become clearer. As highlighted earlier, global values of the two indices are used, thus their levels should characterize aggregated information at the risk of being lost should changes be calculated. This approach of using data in levels for the two indices has also been used by a few other recent studies (e.g., Fameliti & Skintzi (2023; Nonejad (2022); Segnon et al. (2018)).

Across all three regions, the dividend yield emerges as a non-stationary time series with a unit root.

Considering Germany, all except the dividend yield are deemed to be stationary. For Germany's inflation and term spread the results of stationarity outweigh those of a unit root. The results are split for real economic activity, however, considering that failing to reject the ZA null does not imply unit root in series but rather unit root with no break in series, no evidence of a significant structural break is posited. Thus, real economic activity is treated as stationary. Considering potential breaks, only the term spread and the short-term interest rate reject the null of the ZA test, suggesting that the series are stationary after accounting for the structural break. Owing to this, despite the ADF, PP, and KPSS tests indicating short-term interest rate in Germany as nonstationary with unit root, it is considered stationary by relying on the ZA results after accounting for the structural break. Based on these results, the lag-one difference of the dividend yield will be used.

In case of the UK, applying a similar reasoning as above leaves the dividend yield as non-stationary with a unit root. Additionally, inflation is another variable found to have a unit root. Although the term spread and the short-term interest rate show a unit root through the ADF, PP, and KPSS tests, the ZA results show both the series to be stationary after accounting for structural breaks in each. Thus, precedence is given to the ZA result. All remaining variables for the UK, i.e., real economic activity, term spread, and short rate are thus stationary.

For the US, in addition to the dividend yield, the term spread is also found to have a unit root, while the remaining variables are stationary. In this case as well, due to the ZA test result showing the short-term interest rate to be stationary after accounting for a structural break, the unit root results of the previous tests are usurped in favour of stationarity after accounting for the structural break.

Table 3. Correlation analysis.

Panel A: Germany							
	GERREA	**GERINF**	**GERTS**	**DGERDY**	**GERi3**	**logGPR**	**logEPU**
GERREA	1						
GERINF	0.34***	1					
GERTS	0.59***	0.09	1				
DGERDY	-0.28***	-0.11	-0.18**	1			
GERi3	-0.33***	0.17**	-0.18**	0.15*	1		
logGPR	0.07	-0.06	0.18	-0.03	-0.06	1	
logEPU	-0.12*	-0.24***	-0.29***	0.02	-0.61***	0.07	1
Panel B: The UK							
	UKREA	**DUKINF**	**UKTS**	**DUKDY**	**UKi3**	**logGPR**	**logEPU**
UKREA	1						
DUKINF	-0.02	1					
UKTS	-0.01	0.01	1				
DUKDY	-0.04	0.02	-0.11*	1			
UKi3	-0.16**	0.02	-0.79***	0.08	1		
logGPR	0.10	0.04	0.12*	-0.01	-0.03	1	
logEPU	0.11*	-0.06	0.31***	0.07	-0.69***	0.07	1
Panel C: The US							
	USREA	**USINF**	**DUSTS**	**DUSDY**	**USi3**	**logGPR**	**logEPU**
USREA	1						
USINF	0.48***	1					
DUSTS	-0.12*	-0.15**	1				
DUSDY	-0.23***	-0.12*	-0.16**	1			
USi3	-0.27***	0.34***	0.02	0.08	1		
logGPR	0.18***	0.07	0.00	0.00	-0.27***	1	
logEPU	0.07	-0.25***	0.06	0.01	-0.53***	0.07	1

Notes: The asterisks indicate significance levels with * representing the 10% level, ** representing the 5% level, and *** representing the 1% level.

As per Table 3, stronger and more significant correlations are exhibited between *logEPU* and the financial and macro variables for Germany, the UK, and the US compared to *logGPR*, however, significant albeit weak correlation is found between *logGPR* and US real economic activity, and mild and significant correlation is found between *logGPR* and the US short-term interest rate. Across the three countries, highly significant and rather strong correlation is found between *logEPU* and the short rate. Additionally, *logEPU* is found to have highly significant moderate correlation with the term spread in Germany and the UK, and with inflation in Germany and the US. No significant correlation was found between the log values of the two indices themselves.

4.2 Empirical Methods

Vector autoregression (VAR) is a methodology by which the relationships among interdependent multiple time series can be analyzed. With more than one response variable being involved, VAR allows for bidirectionality in the underlying interdependencies between the time series variables, i.e., *a* can be a function of *b,* and *b* can be a function of *a.* As described by Brooks (2019), the VAR model can be considered a blend between univariate models and simultaneous equations models, only they allow for more complexity than univariate models, and better ease of generalization than large-scale simultaneous equations models. The intuition behind the VAR is to model each response variable as a linear combination of the lagged values of itself, as well as the lagged values of other variables under consideration, in addition to the error terms (Brooks, 2019). The two-lag VAR model, i.e., VAR (2) was revealed to be optimal for Germany, the UK, and the US, which can be expressed in the following standard form:

$$y_t = A_0 + A_1 y_{t-1} + A_2 y_{t-2} + \varepsilon_t \qquad (1)$$

Where y_t is an $n \; x \; 1$ vector of endogenous variables at time t, A_0 is an $n \; x \; 1$ vector of intercepts, A_1 and A_2 are $n \; x \; n$ coefficient matrices, y_{t-1} and y_{t-2} are $n \; x \; 1$ vectors of endogenous variables lagged at time $t-1$ and $t-2$, respectively, and ε_t is $n \; x \; 1$ vector of white noise error terms at time t with zero mean, zero autocorrelation, however realistically, contemporaneous correlation amongst the error terms is allowed such that $\mathrm{Cov}(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij}$ (Brooks, 2019; Enders, 2015)

As suggested by Brooks (2019), Enders (2015) and Lütkepohl (2005), economic and/or financial theory and analysis were utilized in ordering the variables within the VAR system for each of the three regions in terms of decreasing exogeneity:

$$y_t = [logGPR, logEPU, i3, TS, DY, INF, REA] \qquad (2)$$

Such an ordering represents the effect of any possible contemporaneous correlation amongst the variables to flow from the first variable to the second and so on, i.e., the effect of the GPR index on the EPU index, which then affect $i3$, TS, and DY, which then affect the inflation rate and real economic activity (Caldara & Iacoviell, 2022). The attributes of the GPR and EPU indices discussed in the literature review back this assumption, as well as for the role of the conventional financial market variables as the "control variables". The explanatory variables and the control variables are thus asserted to explain the response variables of the inflation rate and real economic activity.

To determine the number of lags to include for each equation in the VAR system, the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were relied upon. As the likelihood ratio test allows for the goodness of fit of two nested models to be evaluated, in the case of VAR, this logic extends to evaluate the goodness of fit between a model with a lower lag order and that with a higher lag order. Following are the null and alternative hypotheses of the likelihood ratio test:

H_0: The higher order model does not fit the data significantly better than the lower order model; the log-difference between the two models is zero.
H_1: The higher order model fits the data significantly better than the lower order model.

Once the VAR model is estimated, the diagnostics and goodness-of-fit were evaluated. Model stability checks were conducted based on eigenvalues and the cumulative sum test, as well as the checks of serial correlation, heteroscedasticity, and the normality of residuals based on the Jarque–Bera test, skewness, and kurtosis (Lütkepohl, 2005).

The Granger causality test was used to assess whether the current and lagged values of a time series are useful in predicting the values of another variable (Stock & Watson, 2020). Considering equation (1), y_i can be said to Granger-cause y_j if some coefficient of A_{ji} is non-zero (Moraffah et al., 2021). More specifically, for Granger causality to hold between two variables, the following condition should be met:

$$\sum_{y}(h|\Omega_t) < \sum_{z}(h|\Omega_t \setminus \{y_s|s \leq t\}) \quad \text{for at least one } h = 1,2,.... \tag{3}$$

Where, $\sum_z(h|\Omega_t)$ represents the minimum MSE of the forecast derived from the optimal h-step predictor of process y_t at time t, Ω_t represents a set of all relevant information available at time t, $\{y_s|s \leq t\}$ represents the set of variables y_s for all time points s less than or equal to t, i.e., the past and present of set of variables y_t, and $\Omega_t \setminus \{y_s|s \leq t\}$ represents the set of all relevant information in Ω_t except for the information in the past and present of process y_t. More simply, this condition states that the information contained in the set $\Omega_t \setminus \{y_s|s \leq t\}$ provides additional predictive power compared to the information contained in the original set Ω_t (Lütkepohl, 2005). Meaning that at least for one specific value of h, the inclusion of the historical variables up to time t improves the accuracy of the conditional expectation, thus suggesting that the prediction of h, at time t, is significantly impacted by the past values of certain variables y_t. Brooks (2019) clarifies that the Granger causality procedure does not test for one time series *causing* another, but tests for correlation between the current value of a time series and the past values of another instead. Thus, the null and alternative hypothesis of the Granger causality test can be expressed as:

$$H_0\text{: Current and lagged values of } \mathrm{y_t} \text{ do not explain current } \mathrm{x_t}$$
$$H_1\text{: Current and lagged values of } \mathrm{y_t} \text{ do explain current } \mathrm{x_t}$$

Orthogonal impulse response functions were useful in providing further insights into the dynamics among the variables. The inference of causality between two variables within a higher dimensional VAR system can be made should a response be exhibited by one variable to an impulse in another (Lütkepohl, 2005).

Using variance decompositions, the proportion of variation in one variable within the VAR system, due to shocks in itself and in other variables were studied, allowing for the determination of which variable and its innovations explain the n-ahead forecast error variance of real economic activity and inflation (Brooks, 2019).

A comparison was then carried out to assess the accuracy of real economic activity and inflation forecasts based on the inclusion and exclusion of the GPR and EPU indices from a VAR (2) system with the defined conventional financial market variables and the two macroeconomic variables in questions. The ordering of the VAR (2) model with the two indices included has been specified in equation (2), whereas the ordering of the VAR (2) model with only the conventional variables is as follows:

$$y_t = [i3, TS, DY, INF, REA] \tag{4}$$

In the forecasting exercise, the VAR (2) including all the variables in question has been referred to as "GPR-EPU-inclusive VAR (2)"; the model with only the EPU index and the financial and macroeconomic variables is "EPU-inclusive VAR (2)"; the GPR index along with the financial and macroeconomic variables has been modelled as "GPR-inclusive VAR (2)"; and the model consisting of only the financial and macroeconomic variables has been referred to as "conventional VAR (2)".

Out-of-sample fixed window rolling forecasts were conducted for 36 months ahead by splitting the data sample for the equation (2) and equation (4) specifications into respective training sets for the period of January 1999 – November 2016 to be used in VAR (2) estimations, and into respective testing sets the period of December 2016 – December 2019 as the actual observed values of the generated forecasts. As per the author's knowledge, the three-year testing set is infrequent in other studies on financial and economic forecasts, especially considering the long training set. However, it is theorized that forecasts three years into the future allow for sufficient time for the short-to-medium term dynamics usually characterized by financial market variables to be realized while also encompassing the medium-to-long term dynamics characterized by the macroeconomic variables themselves, and the policy risks and geopolitical tensions represented by the EPU and GPR indices, respectively.

Forecast accuracy measures were then used to assess how inclusion and exclusion of the GPR and EPU indices fairs in forecasting real economic activity and inflation. Hyndman & Koehler (2006) highlight the usefulness of scale-dependent forecast accuracy measures, when comparing different forecasting models applied to the same time series as well as for forecast comparisons between different time series given that they share a common unit of measurement. Following this, the root mean squared error (RMSE) was used to assess forecast accuracy.

$$RMSE = \sqrt{mean(e_t^2)} \tag{5}$$

As defined by Brooks (2019), the RMSE gives the square root of mean forecast errors squared, thus representing the magnitude of forecast errors with added weightage given to large errors. Minimization of RMSE indicates increased accuracy in forecasts. Hyndman & Athanasopoulos (2018) further clarify that mean-focused forecasts are achieved in case of minimized RMSE. Thus, the mean forecasts and the higher penalty given to large deviations make the RMSE a suitable accuracy measure for real economic activity and inflation forecasts.

Overall inferences regarding dynamic relationships were drawn by investigating causal linkages, examining response patterns over time, and assessing the contributions of different factors to real economic activity and inflation variability. The forecast performances added to the inferences by assessing how useful the underlying dynamics of the VAR (2) variables were in explaining the future of real economic activity and inflation in Germany, the UK, and the US.

5 RESULTS AND ANALYSIS

The essential findings of the VAR analysis and the dynamic relationships among the variables are reported and their implications are discussed in this section. Subsection 5.1 reports the results on the VAR model specifications and estimations for all three countries, in addition to the diagnostics and goodness-of-fit tests. Subsection 5.2 presents the Granger causality test results and the impulse response functions to paint a picture of the dynamic causal relationships. Finally, subsection 5.3 provides VAR-based forecasts of real economic activity and inflation, and their comparisons across models inclusive of the GPR index and the EPU index, and the model consisting of conventional financial and macro variables.

5.1 VAR Estimations

For Germany, the UK, and the US, the VAR (2) model specifications were found to be optimal by comparison of the respective log-likelihood test statistics and critical boundary values. The VAR (2) models for all three countries were deemed fairly well-specified. Stability was ensured by no eigenvalue crossing the unit circle threshold and the OLS-CUSUM test plots showing unbroken confidence intervals, representing no structural breaks in the residuals. Furthermore, the p-value of the ARCH tests indicated no heteroscedasticity. However, presence of autocorrelation and absence of normality among the residuals of the VAR (2) models was also detected. (See APPENDIX A. VAR)

Investigating dynamic interrelationships and forecasting is the center of this research, thus it can be asserted that the presence of serial correlation in the residuals may not significantly affect the key conclusions drawn. Since serial correlation is aimed at diagnosing the statistical assumptions and estimations of VAR, its interpretive implications rest more directly on the VAR coefficients (Enders, 2015; Gujarati, 2002) rather than Granger causality, impulse response functions, and variance decomposition analyses. Furthermore, as pointed out by Lütkepohl (2005), serial correlation in residuals can be relatively inconsequential when forecasting is the research objective.

Additionally, non-normality can be expected owing to the inherent nature of financial and economic variables. This is evident from the skew and especially kurtosis reported in Table 2. Thus, the VAR (2) model specification is considered admissible for further analysis. Figure 11 presents the VAR (2) fit for inflation and real economic activity across the three countries in question. It is worth noting that the VAR (2) fit for inflation time series for all three countries increasingly deviates from the observed values towards the end of the sample period, whereas the model fits the observed values of real economic activity relatively better, except for the UK wherein more instability in the fit is observed.

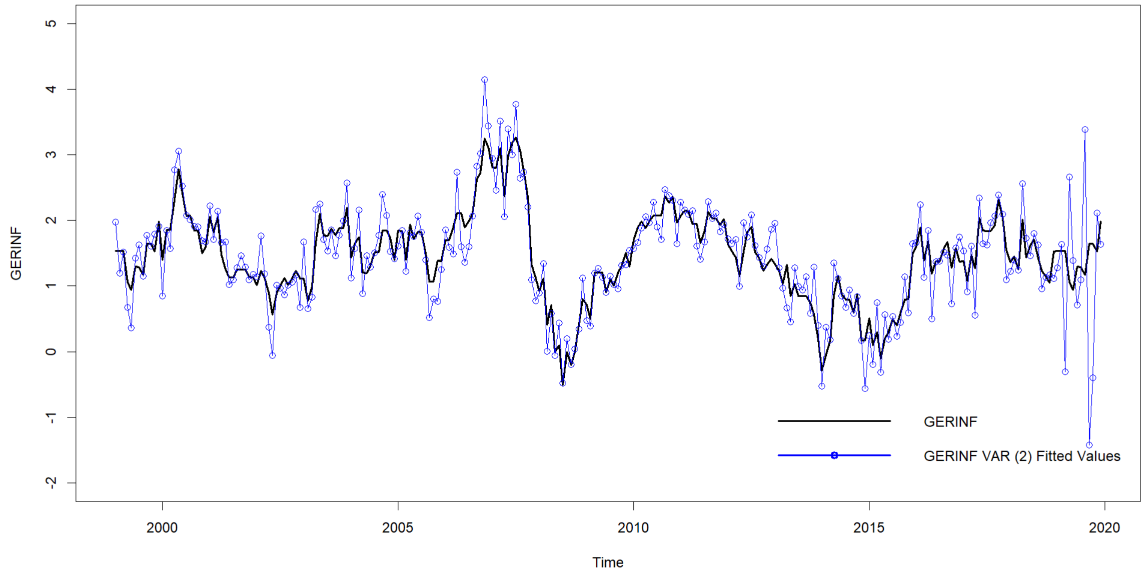


Figure 11. VAR (2) fit for inflation in Germany.

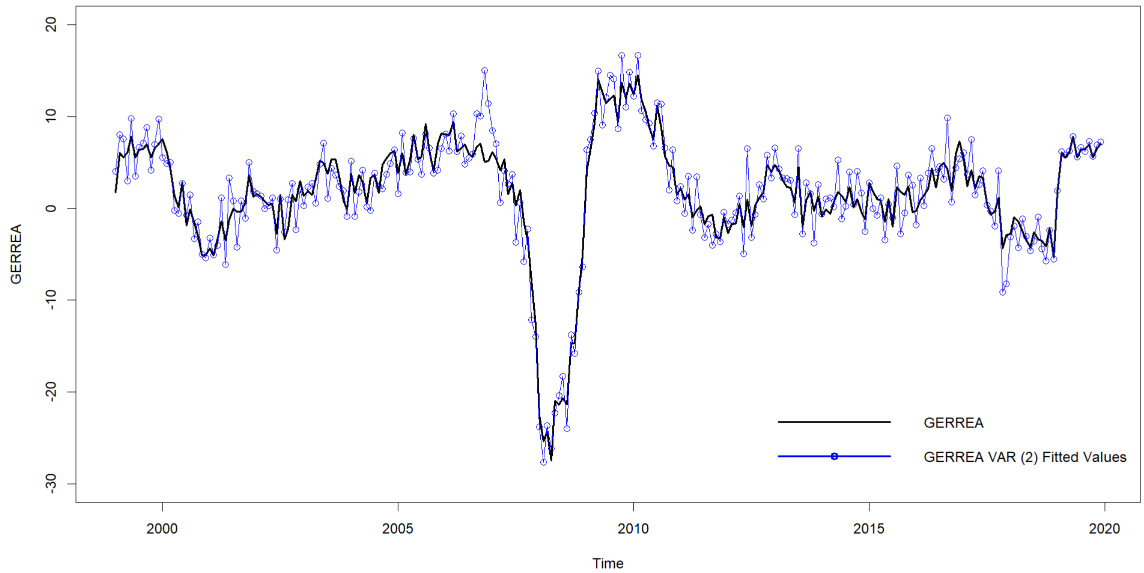


Figure 12. VAR (2) fit for real economic activity in Germany.

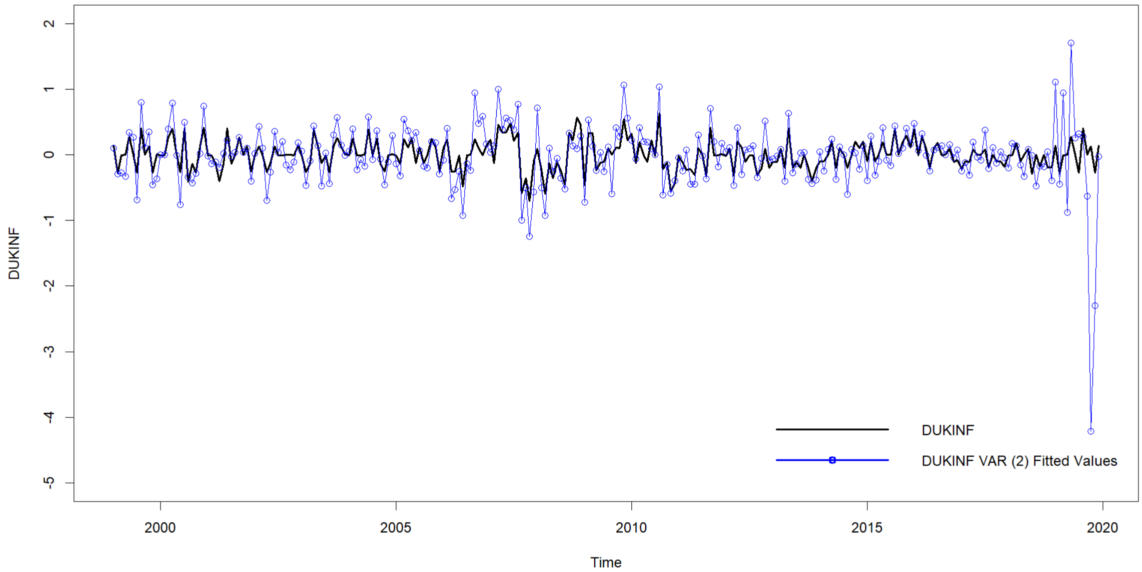


Figure 13. VAR (2) fit for inflation in the UK.

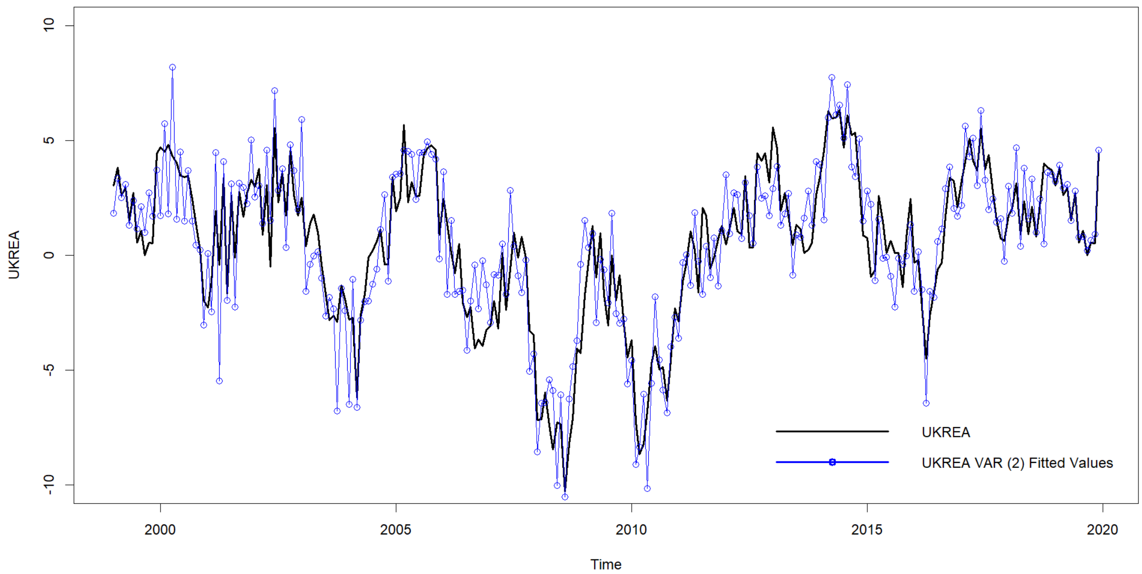


Figure 14. VAR (2) fit for real economic activity in the UK.

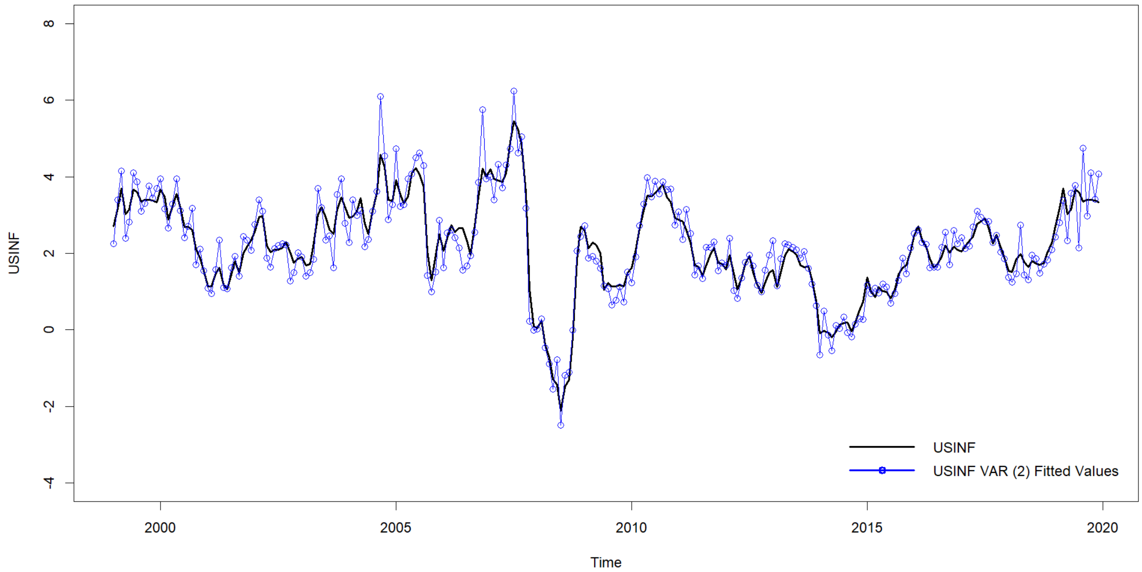


Figure 15. VAR (2) fit for inflation in the US.

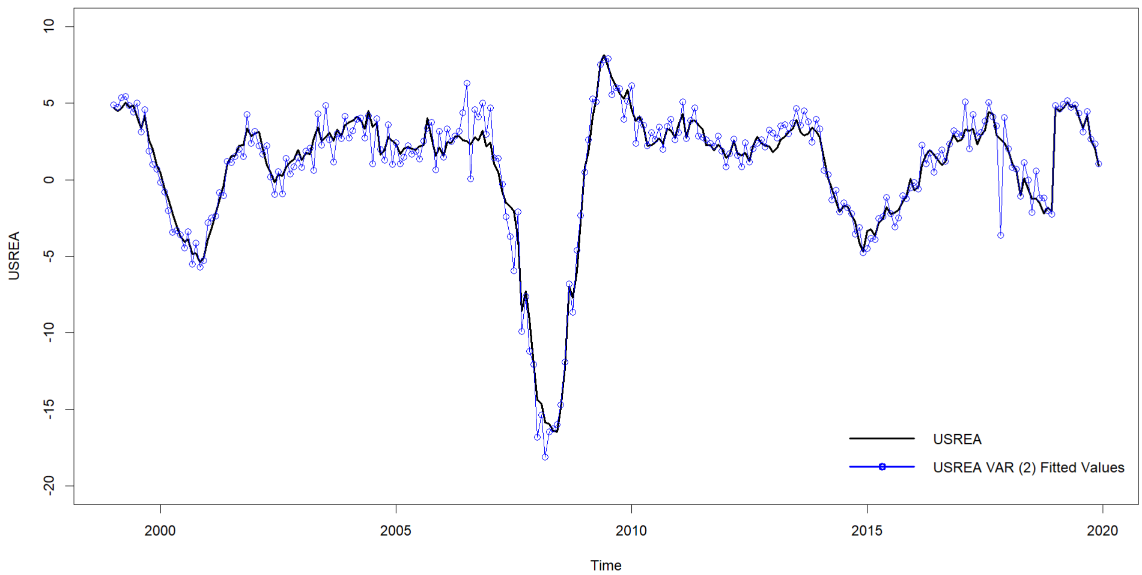


Figure 16. VAR (2) fit for real economic activity in the US.

5.2 Causality

Table 4 presents the Granger causality test results for the three countries. For Germany, logGPR and logEPU were not found to Granger-cause real economic activity or inflation. However, lag-one difference of the dividend yield did Granger-cause logEPU, which itself exhibited causality with the 3-month money market interest rate. The short-term interest rate was then causal to real eco-nomic activity, and to the term spread and the differenced dividend yield. The term spread was another variable Granger-causing real economic activity, as well as the short rate and the differenced dividend yield. Real economic activity was found to Granger-cause the term spread and the differenced dividend yield in return. Real economic activity was also the only variable found to exhibit statistically significant causality with inflation. The causality between real economic activity and inflation was found to be bidirectional, further strengthening the ambiguity around which of the two helps predict which and that the changes in economic activity and inflation mutually affect each other. Further bidirectional causalities exist between real economic activity and the term spread, real economic activity and the dividend yield, term spread and the short-term interest rate, term spread and the dividend yield, and short-term interest rate and the dividend yield. Overall, real economic activity was found to be Granger-caused by the short rate, term spread, and inflation, whereas inflation was found to be Granger-caused by only real economic activity.

It is thus implied that conventional financial and macroeconomic variables provide additional significant information to predict especially real economic activity and, by way of real economic activity, inflation. Nevertheless, it may be argued that since changes in dividend yield possibly explain changes in *logEPU*, which then affect the financial market variables exhibiting Granger-causality with real economic activity, changes in *logEPU* have indirect effects on real economic activity through the short-term interest rate, term spread, and dividend yield. This indirect causality can be argued to extend to inflation as well based on the bidirectional relationship between real economic activity and inflation. It is thus posited that dynamic causal relationships are present among the EPU index and conventional financial and macroeconomic variables for the German context.

Table 4. Granger causality test results for Germany, the UK, and the US.

Panel A: Germany

	logGPR	logEPU	GERi3	GERTS	DGERDY	GERINF	GERREA
logGPR		2.00	0.27	0.32	1.04	0.18	1.75
		(0.14)	*(0.76)*	*(0.73)*	*(0.36)*	*(0.83)*	*(0.18)*
logEPU	0.21		11.69	2.64	1.25	0.36	2.41
	(0.81)		*(0.00)*	*(0.07)*	*(0.29)*	*(0.70)*	*(0.09)*
GERi3	0.83	1.10		13.51	3.73	0.25	12.40
	(0.44)	*(0.33)*		*(0.00)*	*(0.02)*	*(0.78)*	*(0.00)*
GERTS	0.15	2.72	4.63		3.60	2.57	4.31
	(0.86)	*(0.07)*	*(0.01)*		*(0.03)*	*(0.08)*	*(0.01)*
DGERDY	1.11	8.14	1.70	1.25		0.87	2.00
	(0.33)	*(0.00)*	*(0.18)*	*(0.29)*		*(0.42)*	*(0.14)*
GERINF	1.15	0.87	5.01	0.58	1.29		22.10
	(0.32)	*(0.42)*	*(0.01)*	*(0.56)*	*(0.28)*		*(0.00)*
GERREA	0.02	1.38	2.58	2.96	10.57	6.83	
	(0.98)	*(0.25)*	*(0.08)*	*(0.05)*	*(0.00)*	*(0.00)*	

Panel B: The UK

	logGPR	logEPU	UKi3	UKTS	DUKDY	DUKINF	UKREA
logGPR		2.00	0.52	0.35	0.37	0.36	0.06
		(0.14)	*(0.59)*	*(0.70)*	*(0.69)*	*(0.70)*	*(0.95)*
logEPU	0.21		11.06	2.65	0.80	0.91	1.58
	(0.81)		*(0.00)*	*(0.07)*	*(0.45)*	*(0.40)*	*(0.21)*
UKi3	0.53	2.37		5.50	1.42	0.09	0.84
	(0.59)	*(0.09)*		*(0.00)*	*(0.24)*	*(0.92)*	*(0.43)*
UKTS	0.13	0.70	1.56		2.04	0.49	0.80
	(0.88)	*(0.45)*	*(0.21)*		*(0.13)*	*(0.61)*	*(0.45)*
DUKDY	0.86	4.50	9.31	2.10		0.58	1.48
	(0.43)	*(0.01)*	*(0.00)*	*(0.12)*		*(0.56)*	*(0.23)*
DUKINF	0.78	0.04	0.67	0.30	1.68		0.03
	(0.46)	*(0.96)*	*(0.51)*	*(0.74)*	*(0.19)*		*(0.97)*
UKREA	2.07	0.30	1.59	0.92	1.44	0.24	
	(0.13)	*(0.74)*	*(0.20)*	*(0.49)*	*(0.24)*	*(0.78)*	

Panel C: The US

	logGPR	logEPU	USi3	DUSTS	DUSDY	USINF	USREA
logGPR		2.00	0.26	0.55	0.19	0.76	0.69
		(0.14)	*(0.77)*	*(0.58)*	*(0.83)*	*(0.47)*	*(0.50)*
logEPU	0.21		7.17	0.40	3.31	0.35	3.74
	(0.81)		*(0.00)*	*(0.67)*	*(0.04)*	*(0.71)*	*(0.02)*
USi3	0.98	0.77		7.69	3.87	4.52	4.33
	(0.38)	*(0.47)*		*(0.00)*	*(0.02)*	*(0.01)*	*(0.01)*
DUSTS	0.03	2.97	6.06		0.25	1.64	0.15
	(0.97)	*(0.05)*	*(0.00)*		*(0.78)*	*(0.19)*	*(0.86)*
DUSDY	0.44	5.65	6.61	1.50		3.32	0.63
	(0.64)	*(0.00)*	*(0.00)*	*(0.21)*		*(0.04)*	*(0.54)*
USINF	1.56	1.40	4.51	1.49	3.00		8.50
	(0.21)	*(0.25)*	*(0.01)*	*(0.23)*	*(0.05)*		*(0.00)*
USREA	0.52	0.75	5.26	3.59	7.50	5.15	
	(0.60)	*(0.47)*	*(0.00)*	*(0.02)*	*(0.00)*	*(0.00)*	

Notes: The table is to be read from left-to-right such that *logGPR* and its direction of Granger-causality flows from left-to-right in row one, corresponding to the variables in the column headings. The upper values are the F-statistics and the italicized lower values in brackets are the respective p-values. Across the three countries, the short-term interest rate, term spread, and inflation were found to Granger-cause real economic; and only real economic activity was found to Granger-casue inflation.

Noticeably fewer Granger-causal relationships were identified for the UK in comparison to Germany and the US. None of the variables were found to explicitly and significantly Granger-cause real economic activity or inflation, however, a result similar to that of Germany was found whereby lag-one difference of the dividend yield Granger-caused *logEPU*, which then showed causality with the short-term interest rate. In this case, the dividend yield also directly Granger-caused the short-term interest rate. Rather expectedly, the short rate showed causality with the term spread. The absence of causality with real economic activity and inflation implies other variables not included in the model may have a more significant causal impact on the UK economy. Overall, the variables are suggested to be rather weak in causality for the UK context.

The US exhibited the most Granger-causal relationships among the three countries. Here too, lag-one difference of the dividend yield was found to Granger-cause *logEPU*, and the short-term interest rate, as well as inflation directly. In addition to the dividend yield, *logEPU* was found to be Granger-caused by the term spread and was found causal to the dividend yield in return, as well as to the short-term interest rate, and real economic activity. Dividend yield exhibited causality towards the short-term interest rate and inflation, in addition to *logEPU*. The short-term interest rate was then showed to Granger-cause the term spread, inflation, and real economic activity. Overall, Granger-causality was exhibited towards real economic activity by *logEPU*, the short-term interest rate, and inflation. Inflation was found to be Granger-caused by the short-term interest rate, dividend yield, and real economic activity. Furthermore, multiple bidirectional causal relationships were identified, namely that of *logEPU* and the dividend yield, dividend yield and the short rate, dividend yield and inflation, short-term interest rate and the term spread, short-term interest rate and inflation, short-term interest rate and real economic activity, and finally, real economic activity and inflation. The presence of a "feedback loop" is suggested among the relationships indicating mutual Granger-causality. For example, can be argued that the influences of *logEPU* on the dividend yield also act as inputs which influence *logEPU* in return; the influences of the dividend yield on the short-term interest rate also act as inputs which influence the dividend yield in return; and the influences of real economic activity on inflation also act as inputs which influence real economic activity in return.

The lack of Granger causality of *logGPR* with any other variable across the three countries was evident, i.e., changes in the lags of *logGPR* do not explain present values of real economic activity, nor inflation, nor any other variable in the VAR (2) system; nor do changes in lags of any other variable explain the present values of *logGPR*. This is in-line with the findings of Caldara & Iacoviell (2022). However, the absence of Granger causality does not necessarily imply the absence of any relationship between *logGPR* and the other variables. The influence of geopolitical risks on the macroeconomy via more indirect means and/or other variables not included in the model is very much possible. Linearity among time series serves as the theoretical basis of Granger causality, whereas nonlinearities are frequent in empirical observations. Thus, underlying nonlinear dependencies among time series variables can result in discrepant Granger causality estimations (Moraffah et al., 2021; Teräsvirta et al., 2010). On the other hand, (Hassapis et al., 1999) report that the absence of Granger causality among the variables in a VAR system

is an indication that unit roots persist in the system, i.e., non-stationarity within the variables is proposed. This may be due to the structural breaks reported in Table 2. For example, in the study of the predictive power of the GPR index for volatility jumps in the Dow Jones Industrial Average (DJIA), Gkillas et al. (2018) found that, due to nonlinearities and structural breaks, the nonparametric causality-in-quantiles test found significant causality flowing from the GPR index to the DJIA, whereas the standard linear Granger causality test failed to do so.
As previously clarified, Granger causality is correlation between a current time series and another lagged time series. Correlation does not imply causation. Hence, further analysis of logGPR, along with the rest of the defined variables, within a VAR (2) model can uncover additional dynamic relationships and provide insights into the predictive power of the variables, as is intended.

5.3 Dynamic Relationships and Forecasts

This section presents relationships among the variables as characterized by the impulse response functions and variance decompositions, followed by forecasts of real economic activity and inflation based on the VAR (2) specification for Germany, the UK, and the US.

5.3.1 Impulse Response Functions and Variance Decompositions

The impact on real economic activity and inflation in Germany based on one standard deviation shocks in the other variables within the VAR (2) system is shown in Figure B. 1 (APPENDIX B. Impulse Response Functions). Statistically significant impacts were only observed on real economic activity from respective one standard deviation shocks in the 3-month money market interest rate and inflation, along with the impact of one standard deviation shock in real economic activity on inflation. Nevertheless, the direction and magnitude of responses in real economic activity and inflation from shocks in other variables is worth studying as they aid in answering the first and second research questions, while highlighting the need for further analysis that leads to statistically significant results.

The overall response, to a one standard deviation shock in *logGPR*, from German real economic activity was not significantly different from zero. Considering just the magnitude, a year into the future the cumulative impact is expected to change real economic activity in Germany to slightly below -0.2%. Hence, a convergence and persistence back towards its pre-shock levels is expected. German inflation, on the other hand, while not differing from zero in terms of confidence intervals, experienced a rather minute downward immediate response, and recovery was quickly observed, however, the decline returned three months after the shock, becoming negative and persistent till a year in. Overall, a temporary positive impact on German real economic activity is suggested by an increase in the

GPR index, which dissipates rather soon after, and the persistence of the shock leads to a decline in real economic activity. As for German inflation, a negative impact in the medium-to-long term is suggested in response to an increase in the GPR index.

An exogenous shock in *logEPU* does not report a statistically significant response in German real economic activity. Strictly in terms of magnitude, a *logEPU* impulse has the opposite effect compared to *logGPR* for German real economic activity. A year ahead, real economic activity can be expected to be pushed up at approximately 0.4%. Considering the magnitude, German inflation responds to a shock in *logEPU* opposite to real economic activity, but in this case too this result was not significant. Overall, it is suggested that global economic policy uncertainty initially suppresses German real economic activity but leads to subsequent boost in the medium-to-long term, whereas increased inflationary pressures are seen in the short-term, which however diminishes over time to eventually stabilize at the pre-shock level.

Statistically significant impacts on real economic activity and inflation were observed only from shocks in the financial and macroeconomic variables. This finding was consistent with the theoretical and empirical effects of the financial and macroeconomic variables discussed in the previous sections. From the financial variables, an increase in the short rate resulted in significant negative real economic activity two months after the shock and reached its trough at -0.6% four months ahead, after which recovery of significance can be observed till the tenth month where real economic activity can be expected to be -0.5%.

Responses from the two macroeconomic variables to impulses in each other trump the results from the rest of the variables in terms of statistical significance and precision, as indicated by the absence of zero within the confidence intervals, and the narrow width of the confidence intervals, respectively. A shock in inflation was shown to increase in real economic activity from 0.1% to approximately 0.7%, between the first and second period ahead. A decline of significance was then observed until about 3.5 periods ahead, after which the declining response became significant again eight periods onwards. At 12 periods ahead and beyond, German real economic activity can be expected to be at around -0.6%. A shock in real economic activity led to an overall persistent and positive impact on inflation, which became statistically significant from the third period onwards. At 12 periods ahead and beyond, inflation in Germany can be expected to be close to 0.1%. These findings support the real-world mutual connections between the two variables whereby increased inflation may be associated with higher economic activity, while higher economic activity can put upwards pressures on prices, hence contributing to inflation. Distinctly, the observed time lags in the responses of the two variables are representative of the time taken by key decisionmakers to adjust their behaviors and for the effects to propagate through the economy. These findings are also consistent with the forecast error variance decomposition results presented in Figure C. 1 (APPENDIX C. Forecast Error Variance Decompositions) whereby for Germany, majority of the variance real economic activity was found attributable to itself throughout the 12 periods ahead, followed by the short-term interest rate, and inflation, whose proportions were realized the second period onwards. The variance proportion attributable to inflation become smaller in cohesion with the periods of insignificance in Figure B. 1, and the share of the short rate grew larger. After a year, about 20% of real economic activity variance was explained by shocks in mostly the short-term interest rate (making up 12.5%) and inflation (6%). Figure C. 1 further lends support such that majority of the variance in inflation is explained by itself, followed by a shock in real economic activity (17% at a year ahead), the prevalence of which coincides with the periods of significance in Figure B. 1.

Figure B. 2 shows the impact of one standard deviation shocks in the variables within the VAR (2) system on real economic activity and inflation in the UK. The absence of statistical significance is evident in both contexts. This may be indicative of a segregation between the UK and Germany (and the US as the following results will reveal), in terms of economic and financial structures.

Nonetheless, the impulse response functions provide insights into the dynamics between the variables.

Following a one-standard deviation shock in *logGPR*, an overall persistent downward decline was seen in UK real economic activity, save for an upward movement between the third and fourth months ahead. A similar persistent downward decline was seen for inflation in the UK, except for an upward movement between the second and third months ahead. After 12 months, the respective cumulative impacts of *logGPR* on real economic activity and inflation in UK is expected to converge towards zero. Overall, a negative and persistent impact on UK real economic activity and inflation can be expected as log of the GPR index increases in the medium-to-long term, after which, dissipation of the effect of increased global geopolitical risks becomes apparent.

In response to a shock in *logEPU*, a persistent positive increase was observed in UK real economic activity, after a brief downward trend. Thereafter, a higher, constant level was achieved with UK real economic activity expected to stabilize at 0.2%, starting at ten periods ahead, and remaining so a year after and beyond. UK inflation, on the other hand, observed a brief jolt, followed by an equally brief fall beyond the initial level. Convergence towards zero can be expected after a year and beyond. As for the impact on UK inflation, the effects of increased economic policy uncertainty appear relatively limited.

Statistical significance was lacking in the impulses from the financial and macroeconomic variables themselves, thus offering support to the limited causal relationships observed in the UK context. Overall, a lack of significant dynamic relationships is implied for the UK. This is further supported by Figure C. 1, wherein, the forecast error variance decomposition shows an overwhelming majority of the variance in real economic activity and inflation to be explained by the respective variables themselves throughout 12 periods ahead.

Figure B. 3 observes the impact on real economic activity and inflation in response to a one-standard deviation shocks in the VAR (2) system in the US context. Real economic activity was impacted by a shock in *logGPR* as a brief positive jolt to slightly below 0.1% during the second month ahead, after which the positive impact stabilized at a slightly elevated level. After six months, the impact was seen to diminish, and at a year ahead, US real economic activity can be expected to persist below 0%. Considering inflation, a persistent positive increase was found, which peaked six months into the shock and declined steadily thereafter. At 12 periods ahead, US inflation can be expected to be around 0.035% with a sustained deflationary trend. Overall, a contractionary impact can be expected on the US economy in the medium-to-long term, as a result of increased log values of the GPR index, whereas US inflation may experience upward pressures in the medium term, followed by a steady decline.

As was for Germany, a trajectory opposite to the response to *logGPR* was observed for the response of US real economic activity to an impulse in *logEPU*. After a decrease from first to second period ahead, a persistent and positive increase was seen in real economic activity. A year ahead, real economic activity can be expected to be pushed up at approximately 0.2%. On the contrary, inflation exhibited a brief rise, extending above 0% during the second period ahead, till the fifth month, after which deflationary pressures were sustained below 0%, with the expectation of -0.02% inflation at a year ahead. Hence, a dampened US economy can be initially expected as log of the EPU index increases, however the recovery potential and resilience of the US economy then plays its part in stimulating a positive and persistent economic growth. For US inflation, an initial increase in log of the EPU index may contribute to inflationary pressures in the short term, however, the persistence of economic policy uncertainty may lead to falling price levels in the long term.

Impacts of statistical significance were observed in inflation from impulses in the lag-one difference of the term spread, lag-one difference of the dividend yield, and from real economic activity. Thus, strengthening the role of conventional financial market and macroeconomic variables in explaining the overall economy. Noticeably however, none of the conventional variables impacted real economic activity in the US in a significant manner, except for inflation but for too brief of a period three months after a shock. Specifically, a shock in US inflation was found to yield a positive increase in US real economic activity which peaked at three months in, which is where significance was observed. Thereafter, a decline was seen which remained positive until six periods ahead. Persistent negative growth was then observed, with real economic activity expected to be -0.2% at 12 months ahead. A shock in US real economic activity, on the other hand, resulted in a steep, persistent, and positive increase in US inflation until about six periods ahead, after which inflation peaked and stabilized at 0.20% until the eighth period ahead. A steady but slow decline in inflation was then observed with movement towards 0.15% inflation levels seen a year after the shock. Further confirmation of results is found through Figure C. 1 whereby US real economic activity did consistently well in explaining itself, and US inflation saw, in addition to mostly itself, variance proportions attributable to shocks in real economic activity, the differenced term spread, and the differenced dividend yield, coinciding with their respective periods of significance from Figure B. 3. After a year, approximately 57%

of the variance in inflation was explained by itself, and 29% by a shock in real economic activity.

Across the three countries, a one standard deviation shock in the respective log values of the GPR and EPU indices was found to have no statistically significant impact on real economic activity or inflation. Impacts of significance were, however, obtained from impulses in financial market variables and the macroeconomic variables themselves.

The earlier finding of Granger causality from dividend yield to *logEPU* was also common to all three countries in question, hence, Figure B. 4 shows the impact of one standard deviation shocks in each of the variables within the VAR (2) on *logEPU* in the German, UK, and US context. Support for the causality results was found as statistically significant responses were found in *logEPU* from an exogenous shock in the dividend yield of each country. Steep increases can be expected in *logEPU* between the first and second months from 0 to close to or above 0.03, followed by a decrease around 0.02 at three periods ahead. For a shock in the US dividend yield, the impulse in *logEPU* stopped being significant halfway through the second period ahead. Statistical significance was observed in the response *logEPU* of to a German dividend yield shock until the third period ahead, whereas for a shock in the UK dividend yield gave a statistically significant response in *logEPU* until a year ahead, and seemingly beyond.

Notwithstanding statistical significance, dividend yield shock-induced responses in *logEPU* showed persistence into the long-term. While convergence to zero was suggested by the response from the German dividend yield, *logEPU* appeared far from zero at 12 months ahead in response to the UK dividend yield shock, however a decline is indeed observed. In the US context, *logEPU* persisted at 0.01 after a dividend yield shock, into the long-term with no sign of convergence towards zero.

Hence, it can be inferred that an exogenous shock in the respective German and US dividend yields has a positive short-term effect on log of the global economic policy uncertainty index, whereas the impact is long-term from the UK dividend yield. Forecast error variance decompositions of *logEPU* for Germany, the UK, and the US provided in Figure C. 3. Forecast error variance decomposition for logEPU in context of Germany, the UK, and the US in Figure C. 3 are consistent with the inferences made.

Orthogonal impulse responses in *logGPR* from the rest of the variables did not result in statistically significant result for any of the three economies (See Figure B. 5).

In addition to the dynamic relationship between the German dividend yield and *logEPU*, Figure B. 4 reveals a statistically significant response in *logEPU* to a shock in the German term spread and in German real economic activity. In response to the term spread shock, the decline in *logEPU* to slightly below -0.02 remained significant till towards the end of three periods ahead, the steeper part of which occurred between the first two months. Irrespective of significance, *logEPU* remained steady around -0.02 through a year after the initial term spread shock. The resulting decline in *logEPU* to a real economic activity shock, on the other hand, became significant approximately towards the end of five months ahead and remained so a year into the future. Congruence of such was found in the variance decompositions of *logEPU* in the German context (Figure C. 3).

Interestingly, 24-period ahead impulse response functions reveal the significant declining response of *logEPU* to a German real economic activity shock to remain significant and declining till 20 months ahead (Figure B. 10).

In the UK context, Figure B. 6 also suggests for a term spread shock to have a statistically significant impact on *logEPU*, given that the statistical significance began approximately 5 months after the shock, as *logEPU* fell to approximately -0.025, and lasted for about 4 months forward where convergence towards -0.03 was observed. This finding, while consistent with that of Germany, ought to be interpreted with caution as the confidence interval was wider than optimal for a precise result, and its upper limit was rather close to zero.

According to Figure B. 8, a shock to the US term spread too led to a statistically significant decline in *logEPU* from a month after the shock, to a bit more than two months ahead, with *logEPU* being slightly above -0.03 and be maintained so towards the end of three months ahead, after which the response ceased to be significant. Regardless of significance, slow and steady convergence towards zero was observed in the long-term. Furthermore, a US real economic activity shock appeared to result in a persistently declining response in *logEPU* which became significant only 11 months after the shock and continued downwards a year ahead and beyond. As was the case for Germany, a 24-period ahead analysis revealed that the impact on *logEPU* remained significant but steady at around -0.04 until 20 months ahead (Figure B. 11).

5.3.2 VAR-based Forecasts

A comparison of forecast performance of the following models, for real economic activity and inflation across Germany, the UK, and the US, is presented in Table 5: GPR-EPU-inclusive VAR (2), the EPU-inclusive VAR (2), the GPR-inclusive VAR (2), and the conventional VAR (2). Forecasts were conducted on a rolling basis for 36 months ahead, starting at December 2016, up till December 2019.

Overall, it is highlighted by Table 5, that for real economic activity forecasts in Germany and the UK, the GPR-inclusive VAR (2) model yielded the most accurate forecasts relative to the other models under consideration. A similar case was observed for US real economic activity, but with the conventional VAR (2) model also having the same RMSE as the GPR-inclusive VAR (2).

Interestingly, for all three countries, inflation forecasts exhibited the same accuracy measures for all models, with the minor outperformance of EPU-inclusive VAR (2) for the UK, thus suggesting a lack of significant impact of the presence or absence of *logGPR* and *logEPU* across the inflation forecasting models used.

Table 5. Forecast accuracy for real economic activity and inflation in Germany (Panel A), the UK (Panel B), and the US (Panel C)

Panel A: Germany		
	Real economic activity	*Inflation*
	RMSE	
GPR-EPU-inclusive VAR (2)	1.30	0.15
EPU-inclusive VAR (2)	0.97	0.15
GPR-inclusive VAR (2)	0.96	0.15
Conventional VAR (2)	0.98	0.15
Panel B: The UK		
	Real economic activity	*Inflation*
	RMSE	
GPR-EPU-inclusive VAR (2)	0.55	0.15
EPU-inclusive VAR (2)	0.56	0.14
GPR-inclusive VAR (2)	0.54	0.15
Conventional VAR (2)	0.56	0.15
Panel C: The US		
	Real economic activity	*Inflation*
	RMSE	
GPR-EPU-inclusive VAR (2)	0.51	0.25
EPU-inclusive VAR (2)	0.51	0.25
GPR-inclusive VAR (2)	0.42	0.25
Conventional VAR (2)	0.42	0.25

Following GPR-inclusive VAR (2), real economic activity in Germany was shown to be most accurately forecasted by EPU-inclusive VAR (2), and then by conventional VAR (2), and lastly by GPR-EPU-inclusive VAR (2). Furthermore, Table 5 shows that GPR-inclusive VAR (2) forecasts outperformed the EPU-inclusive VAR (2) forecasts in terms of accuracy by 0.01 percentage points (pp), and conventional VAR (2) forecasts outperformed EPU-inclusive VAR (2) forecasts by the same factor.

For UK real economic activity, after GPR-inclusive VAR (2), GPR-EPU-inclusive VAR (2) appeared to result in the most accurate forecasts, followed by EPU-inclusive VAR (2) and conventional VAR (2) exhibiting forecasts of equivalent accuracy. As was the case for Germany, for the UK too, a small difference was observed in real economic activity forecasts by the four models. Additionally, in the UK context, GPR-EPU-inclusive VAR (2) also showed a minor difference in forecast accuracy on par with the remaining models, which it did not for Germany.

For US real economic activity, owing to equivalent RMSE values, GPR-inclusive VAR (2) and conventional VAR (2) were deemed to provide forecasts of equivalent accuracy above the also equivalent forecasts provided by GPR-EPU-inclusive VAR (2) and EPU-inclusive VAR (2) by 0.09 pp. The differences in accuracy were not as negligible for US real economic activity as they were for real economic activity in Germany and the UK.

While even small improvements in forecasts of essential indicators such as real economic activity are crucial, it can also be suggested that the inclusion and exclusion of logGPR and logEPU to/from a VAR (2) model with the defined conventional variables all lead to forecasts of equivalent accuracy for at least German and UK real economic activity.

Figure 17, Figure 18, and Figure 19, show real economic activity forecasts (Part A) and inflation forecasts (Part B) for Germany, the UK, and the US, respectively, based on GPR-EPU-inclusive VAR (2), GPR-inclusive VAR (2), EPU-inclusive VAR (2), and conventional VAR (2).

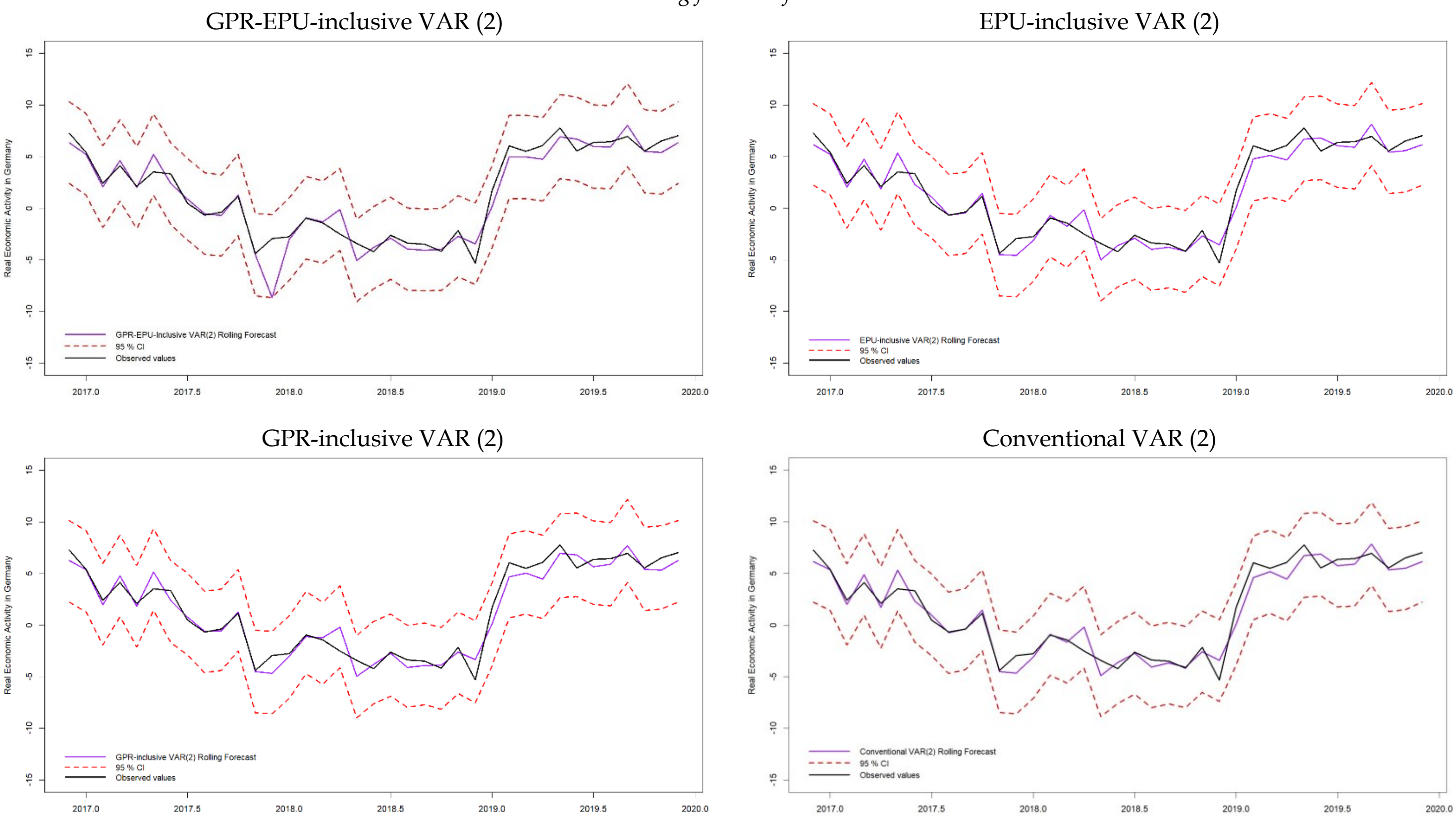
Observably, differences among the forecasts from the different model specifications were not easily discernible. Nonetheless, the reliability of all forecasts is supported by the observed values falling within the 95% confidence interval for the majority part of the forecasts. Inflation in Germany and the US was observed to cut through the upper bound of all forecasts from all VAR (2) specifications towards the end of 2019. This asserts that for Germany and the US, increases in inflation in the later part of 2019 exceeded the forecasts of all the VAR (2) models. A similar occurrence was observed for the GPR-EPU-inclusive VAR (2) and EPU-inclusive VAR (2) forecasts of US real economic activity in late-2019, difference being the lower bound was perforated by the observed values, thus suggesting lower than forecasted (by the two models mentioned) economic growth in the US for 2019-end.

As reflected by the width of the 95% confidence interval, US real economic activity forecasts during December 2018 and January 2019 appeared to offer the most precision of all forecasts, whereas the UK inflation forecast confidence interval is representative of higher uncertainty relative to others.

Common to real economic activity and inflation across the three countries was the directional divergence between the forecasts and the observations towards the end of 2019, while for US inflation divergence was seen earlier around June 2019. The forecasted values were underestimated relative to the observed values, except for US real economic activity, where the opposite occurred. This can be suggestive of economic expansion for Germany and the UK, and a relative underperformance of the US economy. While this period coincides with the onset of COVID-19, the divergence may be more representative of the diminishing performance of the forecasting models as extrapolation uncertainty increases.

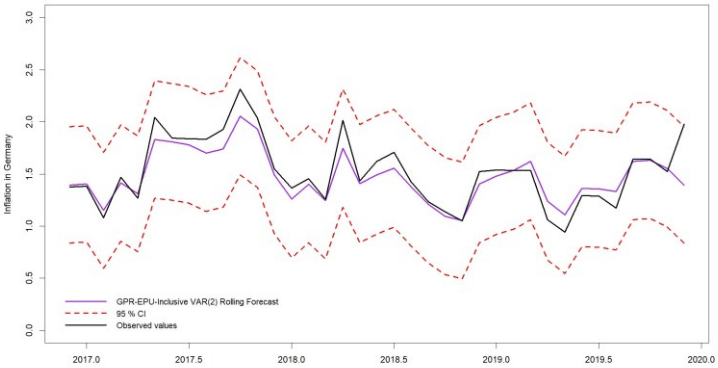
To summarize, GPR-inclusive VAR (2) resulted in forecasts of highest accuracy for real economic activity across the three countries, whereas inflation forecasts from all VAR (2) specifications performed the same, save for the outperformance of EPU-inclusive VAR (2) for the UK context by 0.01

Part A: Rolling forecasts for GERREA

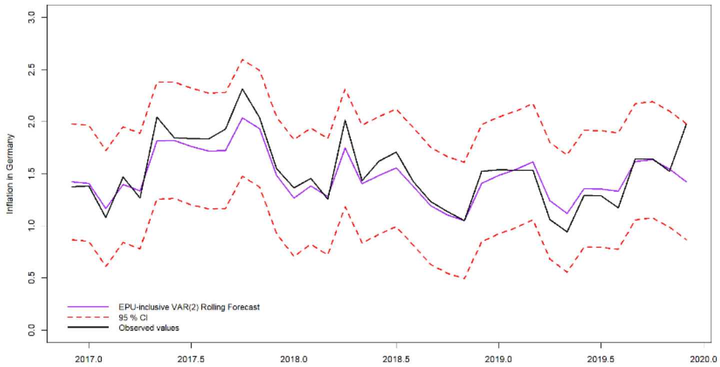


Part B: Rolling forecasts for GERINF

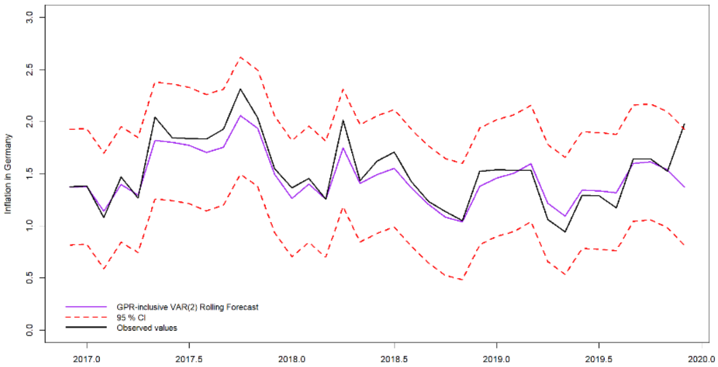
GPR-EPU-inclusive VAR (2)



EPU-inclusive VAR (2)



GPR-inclusive VAR (2)



Conventional VAR (2)

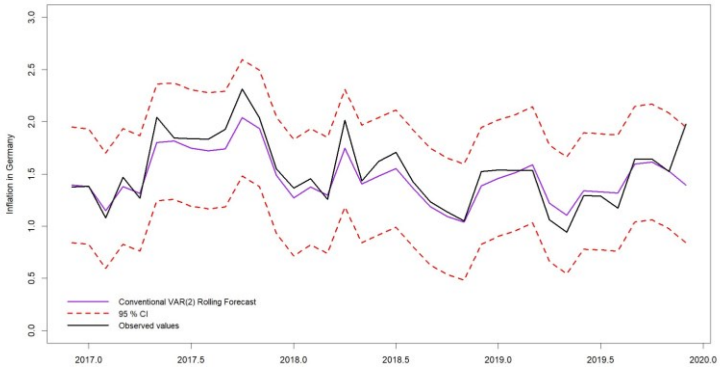
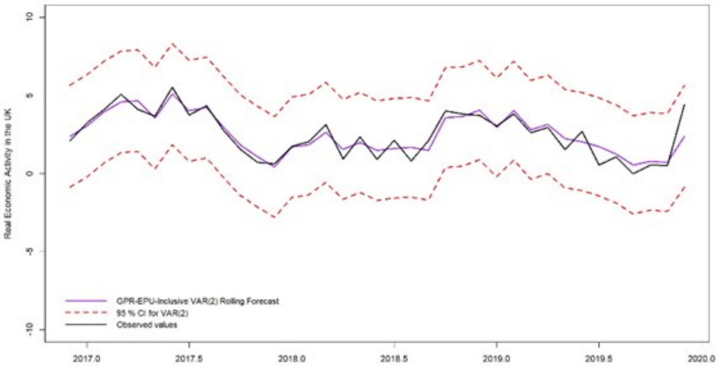


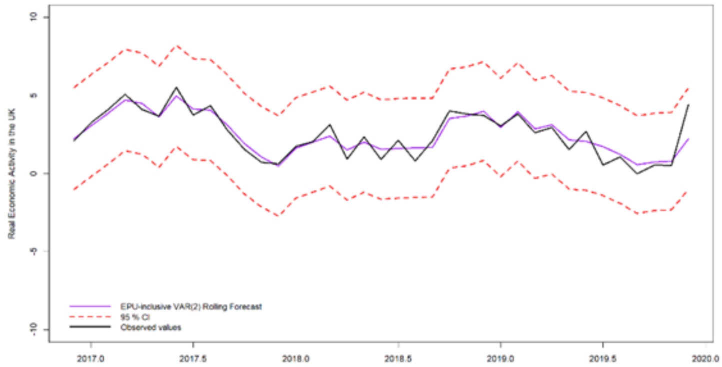
Figure 17. 36-months ahead rolling forecasts for German real economic activity (Part A, *GERREA*) and inflation (Part B, *GERINF*)

Part A: Rolling forecasts for UKREA

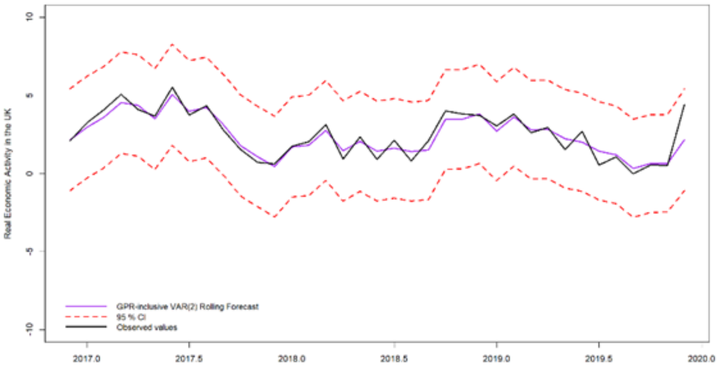
GPR-EPU-inclusive VAR (2)



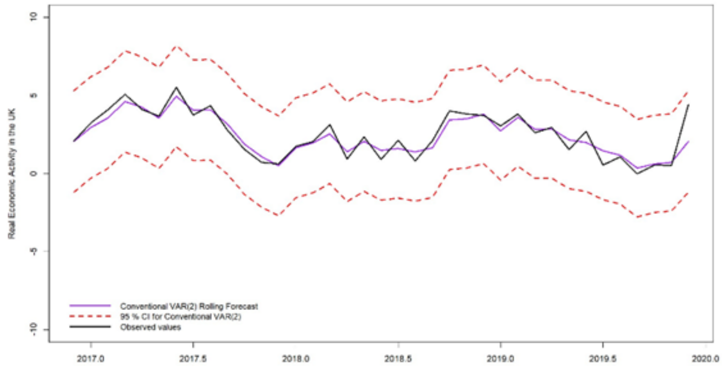
EPU-inclusive VAR (2)



GPR-inclusive VAR (2)

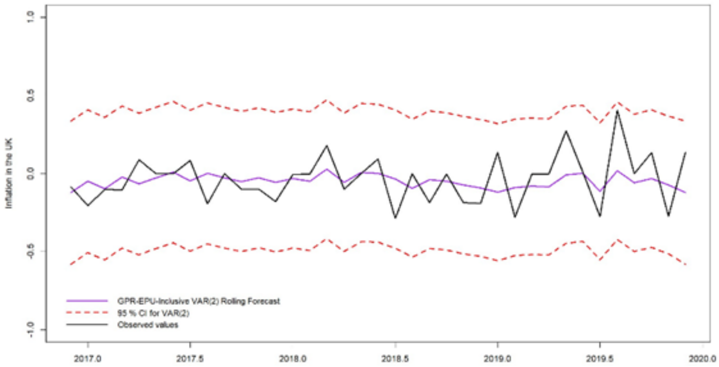


Conventional VAR (2)

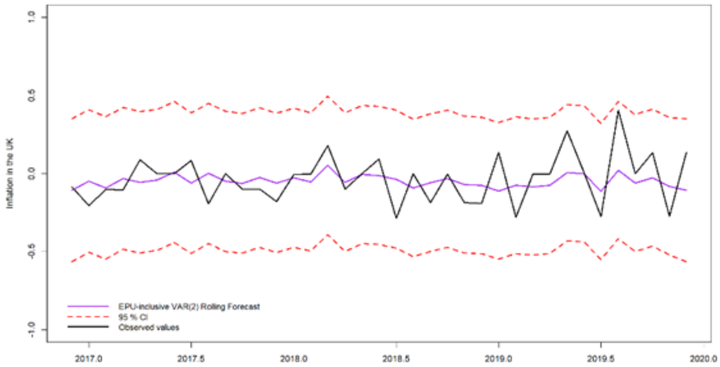


Part B: Rolling forecasts for DUKINF

GPR-EPU-inclusive VAR (2)



EPU-inclusive VAR (2)



GPR-inclusive VAR (2)

Conventional VAR (2)

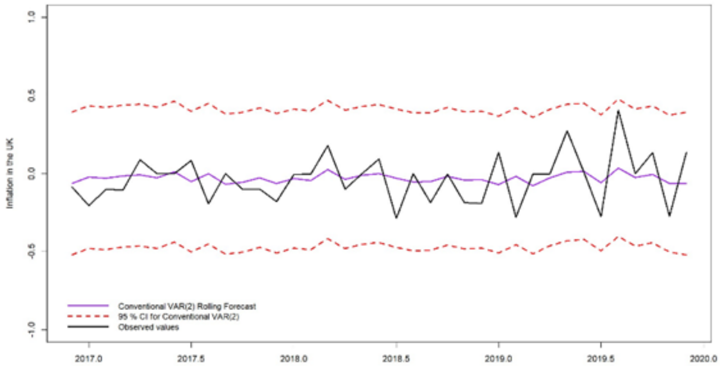
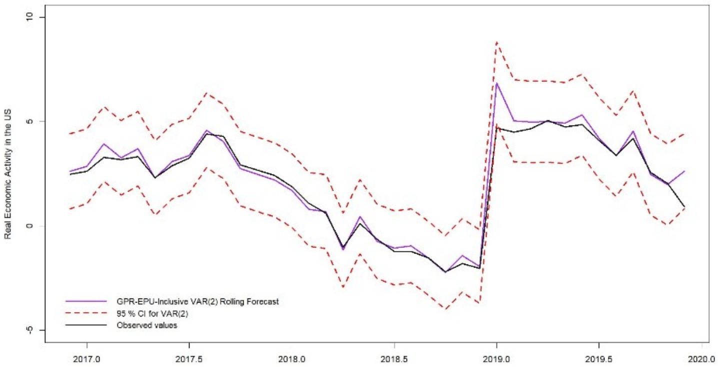


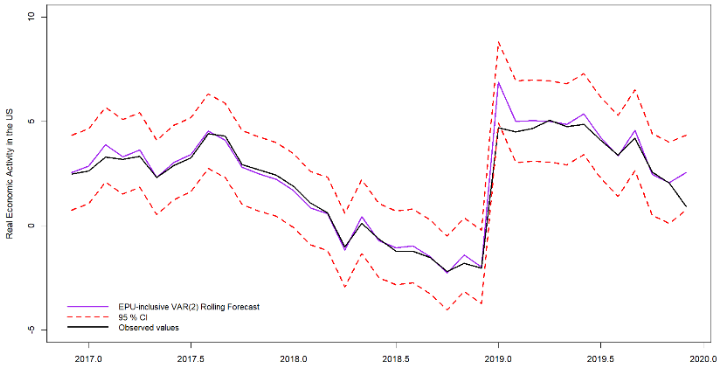
Figure 18. 36-months ahead rolling forecasts for UK real economic activity (Part A, *UKREA*) and inflation (Part B, *DUKINF*)

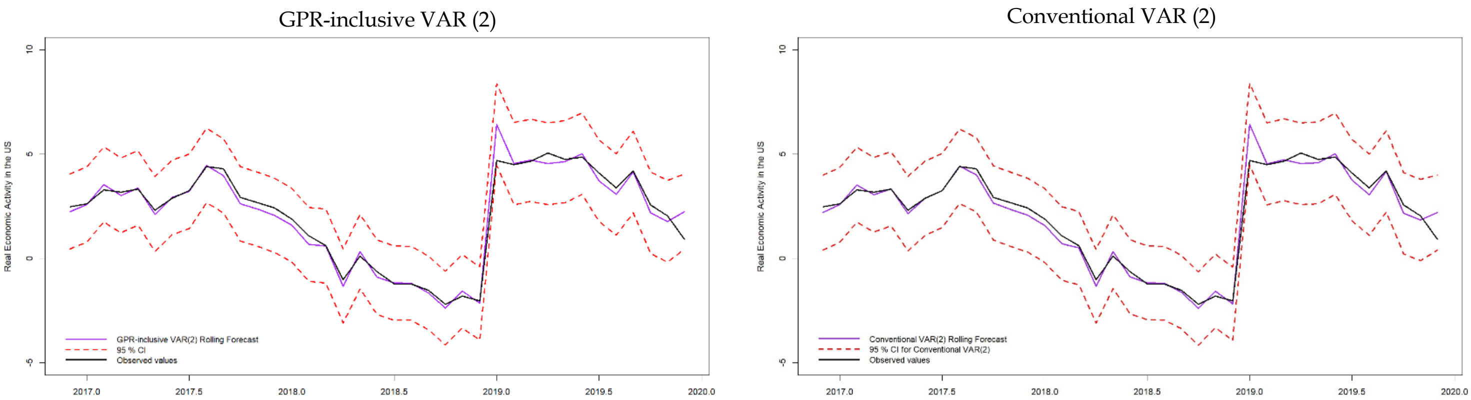
Part A: Rolling forecasts for USREA

GPR-EPU-inclusive VAR (2)



EPU-inclusive VAR (2)





Part B: Rolling forecasts for USINF

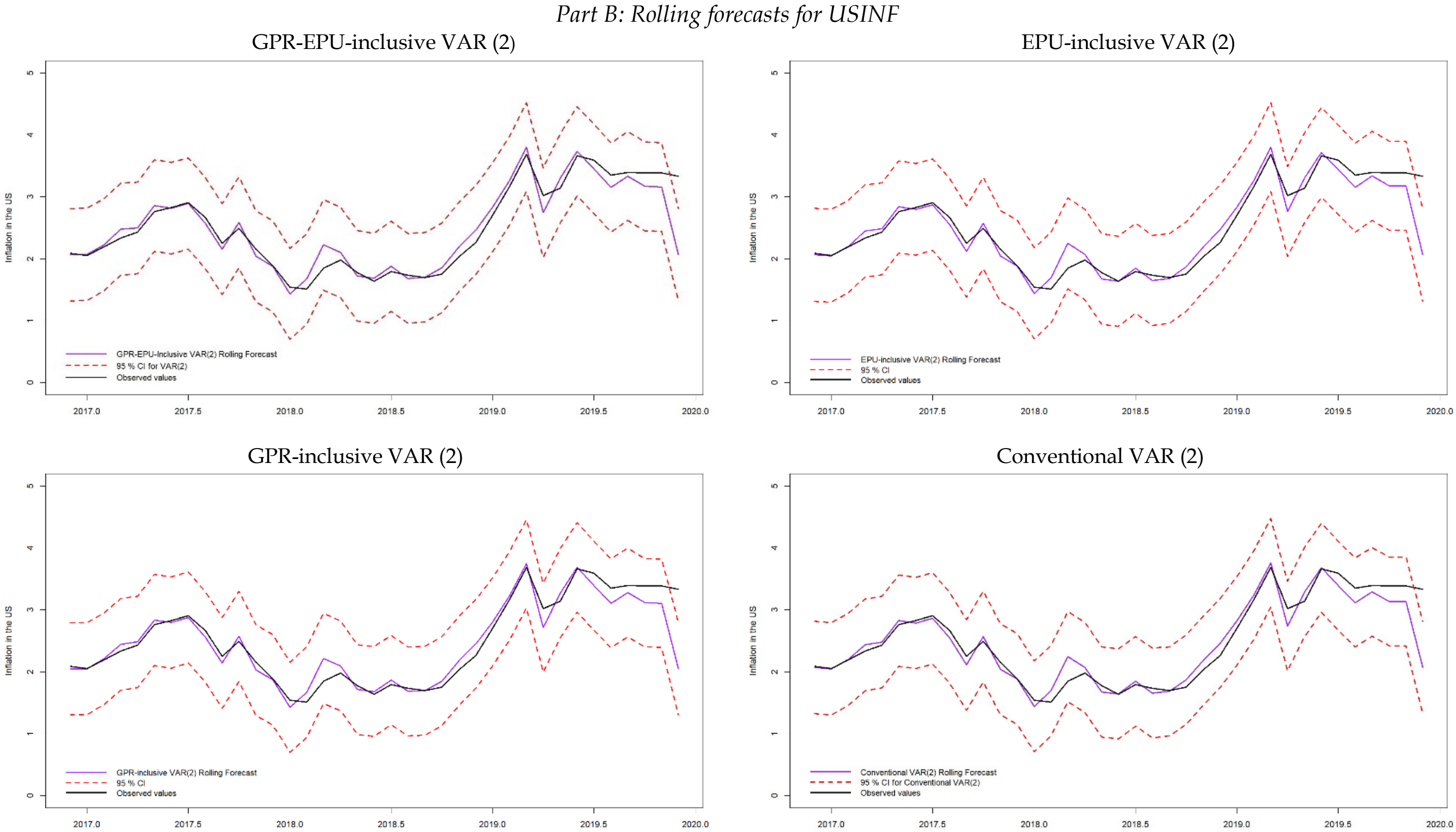


Figure 19. 36-months ahead rolling forecasts for US real economic activity (Part A, *USREA*) and inflation (Part B, *USINF*)

6 DISCUSSION

This section answers each of the three research questions in the form of a discussion based on the results obtained.

What is the impact of the geopolitical risk index and the economic policy index on real economic activity and inflation in Germany, the UK, and the US, and how does it compare to the impact of conventional financial market variables?

For Germany, the UK, and the US, Granger-causal relationships among the EPU index, financial market variables, real economic activity, and inflation were observed. Thus, bringing the role of economic policy uncertainty, in tandem with financial market variables, for forecasting real economic activity and inflation to the forefront. Furthermore, the finding of the preestablished, mutually enforcing, relationship between real economic activity and inflation reinforces the forecasting role of macroeconomic variables for macroeconomic variables. However, it is essential to note that the GPR index, nor the EPU index, were found to be explicitly causal to real economic activity or inflation for any of the three countries. Instead, the causality has been argued to "flow" indirectly from the EPU index to the macroeconomic variables, by way of the financial market variables. The lagged values of dividend yield were found to explain the variation in the EPU index for Germany, the UK, and the US. Subsequently, the EPU index was then found causal to the 3-month money market interest rate for all three countries. Considering the UK and the US, dividend yield also exhibited direct causality with the 3-month money market interest rate, whereas for Germany, the short-rate only came into the picture by way of the EPU index.

For Germany, causality then went from the 3-month money market interest rate to the term spread, dividend yield, and real economic activity. Changes in the term spread were also deemed significant in improving forecasts of the short-term interest rate, dividend yield, and real economic activity. Inflation was found causal to the short-term interest rate and real economic activity. Lastly, lags of real economic activity were found to explain the term spread, dividend yield, and inflation. The presence of multiple bidirectional relationships is evident.

For the UK, the 3-month money market interest rate was expectedly found to exhibit causality with term spread, however, significant causal relationships subsided thereafter. Interestingly however, forecasts of the short-term interest rate were found to be also significantly explained by changes in the dividend yield, in addition to the EPU index. A lack of evident dynamic relationships in the VAR model for the UK is thus suggested.

For the US, an exhaustive network of causal, mutually enforcing relationships was found. In addition to the dividend yield being deemed significant in forecasting the EPU index, and the EPU index being so for 3-month money market interest rate, dividend yield was also found to be Granger-causal to the short rate and inflation. Lagged values of the EPU index were also found to explain current changes in the short rate, dividend yield, and real economic activity. The short-term interest rate was found causal to the term spread, dividend yield, inflation, and real economic activity. The term spread was significant in explaining changes in the EPU index and the short rate. Bidirectional causality between the two macroeconomic variables persisted in the US context as well.

It is thus posited by the causality tests that across Germany, the UK, and the US, conventional financial market variables have more significant impact on real economic activity and inflation, in addition to the macroeconomic variables themselves, compared to the GPR index and the EPU index. Nonetheless, the indirect causality flowing from the dividend yield to the EPU index, and onto the financial (including the dividend yield) and macroeconomic variables is noteworthy and suggests a feedback loop, in no particular order, among the macroeconomy, financial markets, and uncertainty around policy decisions.

Findings of Granger causality tests are supported by the impulse response functions whereby no statistically significant impacts were found on real economic activity or inflation in response to an exogenous shock to the GPR index or to the EPU index, across the three countries, and only the role of financial and macroeconomic variables was determined to be significant in explaining real economic activity and inflation. The forecast error variance decompositions of the macroeconomic variables for all three countries corroborate this finding.

For Germany, relevant impacts were observed on real economic activity through an increase in the 3-month money market interest rate and inflation, and on inflation through an increase in real economic activity. Impact from the short-term interest rate on real economic activity was realized in the medium term with an initial decrease followed by gradual dissipation of the shock, whereas significant increase from inflation first came about in the short-term and then again, in the long-term but in opposite direction. Impact from real economic activity as consistent inflationary pressures persevered from short to long-term. The forecast error variance decomposition results confirmed these findings, with majority of variance in real economic activity determined by itself over the 12 periods ahead, and notable contributions by respective shocks in the short rate and inflation.

For the UK, no statistically significant dynamic responses were found within real economic activity and inflation to impulses in the VAR (2) model, not even between the macroeconomic variables. Variance decompositions, too, reveal the variance in each of the macroeconomic variables to be characterized by themselves. This suggests that the VAR (2) model is mis-specified for the UK, along with potential unaccounted variables influencing real economic activity and inflation beyond those included in the analysis. Furthermore, the UK may be argued to be structurally different to Germany and the US in terms of the overall economy, make up of its financial markets, and policy framework.

For the US, too small and brief of a significant positive response was observed in real economic activity for an impulse in inflation to be realistically impactful. Inflation, on the other hand, responded significantly to increases in the term spread, dividend yield, and real economic activity, with the impact being rather small and brief, positive and short-term followed by deflationary pressures, and positive and medium-term followed by gradual dissipation into the long-term, respectively. Support is provided by the forecast error variance decompositions as real economic activity consistently explained majority of variations in itself, and inflation variance consisting of shocks in itself, real economic activity, term spread and dividend yield.

Based on these results, it is thus argued that the financial market variables are the "causal connections" through which the forecasting role of the EPU index is conceived for real economic activity and inflation, especially for Germany and the US. The specifics of the financial variables do, however, differ across the countries and across the macroeconomic variables.

How do the effects of geopolitical risks and economic policy uncertainty on real economic activity and inflation interact with each other?

The two indices have very limited interactions with each other as neither show Granger causality nor significant responses to shocks in each other (Figure B. 12) with majority of the variance in each being explained by their own shocks (Figure C. 2 and Figure C. 3). Their impacts on real economic activity and inflation have been found to be intrinsically different such that the EPU index has been shown to have an indirect impact via the financial market variables, whereas no impact, direct nor indirect, was identified for the GPR index. It is plausible to thus conclude that geopolitical risks and economic policy uncertainty, as proxied for by the indices, affect real economic activity and inflation in a segregated manner. I.e., geopolitical risks and policy uncertainty, as captured by their respective indices, entail separate types of doubts and apprehensions, which are not transferred to the overall economy in an integrated manner. This may very well be due to the inherently different sources of uncertainty stemming from strict geopolitics and that from economic policy decision-making.

It is however worth noting that for Germany, the UK, and the US, the GPR index and the EPU index had opposite impacts on the macroeconomic variables, especially real economic activity, given that these movements were not statistically significant.

All three economies were found to contract in the long-term in response to an increase in the GPR index. For Germany and the US, short-term periods of economic growth were however observed immediately after the geopolitical shock, whereas the UK maintained an overall consistent decline.

With increases in economic policy uncertainty, on the other hand, it was inferred that economic expansion can be expected in the long-term after a declining immediate response. Essential to this inference is the preceding brief adjustment period wherein falls in real economic activity occur as this period may be characterized by possible corrective measures.

Deflationary pressures in the long-term were observed in response to an increase in the GPR index across the three countries with inflation in Germany and the UK exhibiting almost identical trajectory of responses, except for a slightly higher magnitude of change for UK, with inflation falling till two months in, increasing back to initial levels, and then maintaining a consistent downward descent. In the short-to-medium term, all three countries exhibit an increase in inflation in response to a global geopolitical shock, albeit of differing magnitudes.

The opposite held true for responses in inflation to an increase in global economic policy uncertainty again for Germany and the UK as inflation rose in the short-term only to fall three months into the shock and thus gradually settle around 0% in the long-term. The response of US inflation to an increased EPU index mimicked that of an increased GPR index in the short-term and at a smaller scale. The long-term saw deflationary pressures persist with price levels below the pre-shock levels.

These observations highlight the detached and opposing effects of geopolitical risks and economic policy on real economic activity and inflation, and the lack of explicit interplay between those effects.

Furthermore, following the causal relationships between the dividend yield of each country and the EPU index, which posit that changes in the dividend yield of Germany, the UK, and the US can help explain and forecast changes in economic policy uncertainty, impulse response functions provide further insights. An exogenous shock in the dividend yield of each country leads to a statistically significant, steep, and positive increase in the EPU index in the first and second months, reaching levels around 0.03. However, the statistical significance of the response of the EPU index to an impulse in dividend yield differs in duration across the three countries. In Germany, significance is maintained in the response from one until three months after the dividend yield shock; in the UK, the response remains statistically significant for up to a year ahead; and in the US the significance of the response diminishes halfway through the second month ahead.

It is hence implied that should the German and/or US dividend yields experience sudden increases, an immediate increase in economic policy uncertainty globally can be expected accompanied with quick recovery, whereas an unexpected increase in the UK dividend yield is suggested to influence global economic policy uncertainty in a more prolonged manner. This may be indicative of the UK markets and economy having heavier influence on global markets and trade, over Germany and the US.

Another such dynamic relationship was unveiled to exist between the EPU index and the term spreads of each country, as well as the EPU index and real economic activity of Germany and the US. The term spreads incited a short-term declining impact on the EPU index, whereas real economic activity led to a long-term decline. These findings reflect the existence of lesser economic policy uncertainty globally as the term spread of Germany, the UK, and the US widens (i.e., positively sloped yield curve) and economic activity increases.

The prevalence of the relationship between the term spread and the EPU index also highlight the relationship between the EPU index and the 3-month money market interest rate. While this may be rather intuitive to infer, it was also statistically confirmed as the EPU index was found to Granger-cause the short-term interest rate of all the three countries. Impulse response functions confirmed this relationship as the short-term interest exhibited negative responses starting four-five months into an increase in global economic uncertainty and persisting in the long-term. The role of the short-term interest is further strengthened as not only is it an essential tool in policy transmission, but also in the transmission of its accompanying uncertainties.

Overall, in addition to the segregated impacts of economic policy uncertainty and geopolitical risks on the macroeconomic variables, the outmatch of economic policy uncertainty is highlighted in terms of cohesion with financial market variables and the following indirect impacts on the economy.

Does the inclusion of the geopolitical risk index and economic policy uncertainty index improve the accuracy of real economic activity and inflation forecasts compared to using conventional financial market variables alone?

For real economic activity in Germany and the UK, the GPR-inclusive VAR (2) model yielded the most accurate forecasts relative to the other models, however, this outperformance was by a rather small margin. For real economic activity in the US, GPR-inclusive VAR (2) and conventional VAR (2) yielded equally accurate forecasts over the other models by a more prominent margin. Forecasts for real economic activity of the lowest accuracy were given by GPR-EPU-inclusive VAR (2) for Germany and the US, and EPU-inclusive VAR (2) and Conventional VAR (2) for the UK.

For each country, inflation forecasts performed overall the same for each model.

Overall, the results indicate that the inclusion of the GPR index in a model with other conventional financial market variables, improves forecast accuracy of real economic activity for Germany, the UK, and the US, over that of conventional financial market variables. It is also indicated that models inclusive of the EPU index underperformed in the out-of-sample forecasts. Hence, it is suggested that despite more dynamic relationships being found between the EPU index and the financial and macro variables, they did not translate into improved forecasts for real economic activity, and the more hidden dynamics between the GPR index and the financial and macro variables did translate so. These hidden dynamics were failed to be captured by the VAR analysis applied, including Granger causality tests and impulse response functions. For inflation forecasts, the inclusion of the two indices did not appear to be significant as all models yielded forecasts of equivalent accuracy across the three countries, thus suggesting no improvements in accuracy of inflation forecasts, except for the minute improvement offered by the EPU-inclusive model for the UK. The high uncertainty of UK inflation forecasts, however, restrict the position of any concrete conclusions in this regard.

7 CONCLUSIONS

In studying the dynamic relationships between the global GPR and global EPU indices with key financial macroeconomic variables, this thesis contributes to existing literature on how various forms of uncertainties impact the financial markets and economies. Furthermore, this thesis makes the novel contribution of studying and comparing the out-of-sample forecasting content of the global GPR and global EPU indices for real economic activity and inflation, an aspect not previously covered to the knowledge of the author.

One of the key findings highlighted in this research is the dynamic relationship between the dividend yield and the EPU index, whereby changes in the dividend yield of Germany, the UK, and the US are argued to help explain changes in economic policy uncertainty. Additionally, the dynamics between the EPU index, the term spread, and the 3-month money market interest rate, were also highlighted.

While the EPU index showed more cohesion with the financial market and the overall economy, it lacked in providing information that would improve upon real economic activity forecast accuracy. Thus, another key finding of this thesis is the improved forecasts offered by the GPR index when augmented with conventional financial market variables. The role of the GPR index in shaping real economic activity was however not encompassed by the overall VAR analysis.

It is thus suggested that while the EPU index provides important information on the dynamic interactions between economic policy uncertainty, the financial markets, and the economy, it may not provide reliable and consistent information for forecasting future real economic activity or inflation for Germany, the UK, and the US. The GPR index on the other hand, is highlighted as an important predictor of future real economic activity, despite lack of significant dynamic relationships identified. This means that geopolitical risks emerge as a significant factor that should be incorporated into forecasting models for real economic activity. Forecasting inflation remains a daunting task as neither the inclusion nor the exclusion of either of the indices improve its forecasts over conventional variables.

However, the conclusions made are based on the models and data specific to this thesis. Further research and analysis may be required to validate and generalize these findings across different time periods, countries, and economic contexts. Further research could also improve upon this thesis by explicitly treating the GPR index as an exogenous variable, e.g., using VARX modelling, as its exogeneity has been observed throughout this research. UK inflation could have also been treated in levels and not as changes in the inflation rate for better comparability and reliability, however, the presence of a unit root demanded as such. Furthermore, stock and bond market volatility can be utilized over returns, as suggested by e.g., Gkillas et al. (2018), among others.

Nonetheless, the insights gained from this research have implications for policymakers, investors, and analysts in their efforts to assess and forecast real economic activity and inflation in an uncertain and interconnected global landscape.

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APPENDIX A. VAR

According to Table A. 1 below, for the case of Germany and the UK, the log-likelihood test statistic was found to be greater than the critical boundary value, rejecting the null hypothesis in favor of the alternative whereby the unrestricted model, i.e., VAR (2) model, fits the data better than the restricted VAR (1) model. As for the US, in comparison with VAR (1) model, both VAR (2) and VAR (3) were found to be better fits, and the comparison between VAR (2) and VAR (3) revealed a log-likelihood test statistic smaller than the critical value, thus failing to reject the null of the higher order model not fitting the data significantly better than the lower order model, i.e., there is no statistically significant information added by VAR (3), thus VAR (2) is used.

Table A. 1. VAR lag selection as per information criteria and the log-likelihood ratio test for Germany (Panel A), the UK (Panel B), and the US (Panel C).

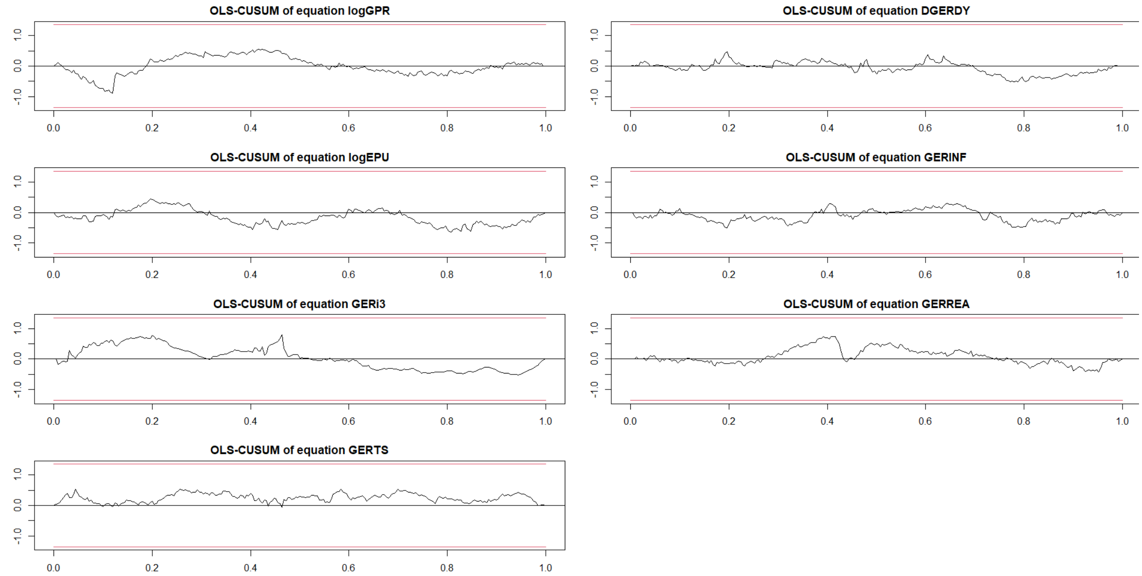
	Panel A: Germany			
	AIC(n)	**HQ(n)**	**SC(n)**	**FPE(n)**
Lags	2	2	1	2
LR-Stat	230.63			
x_c^2	129.92			
	Panel B: UK			
	AIC(n)	**HQ(n)**	**SC(n)**	**FPE(n)**
Lags	2	2	1	2
LR-Stat	170.32			
x_c^2	129.92			
	Panel C: US			
	AIC(n)	**HQ(n)**	**SC(n)**	**FPE(n)**
Lags	3	2	1	3
Lags	1 vs 3	1 vs 2	2 vs 3	
LR-Stat	310.95	201.69	109.27	
x_c^2	183.96	129.92	183.96	

Following are the diagnostics ran on the VAR (2) model for all three countries:

Table A. 2. Diagnostics Results

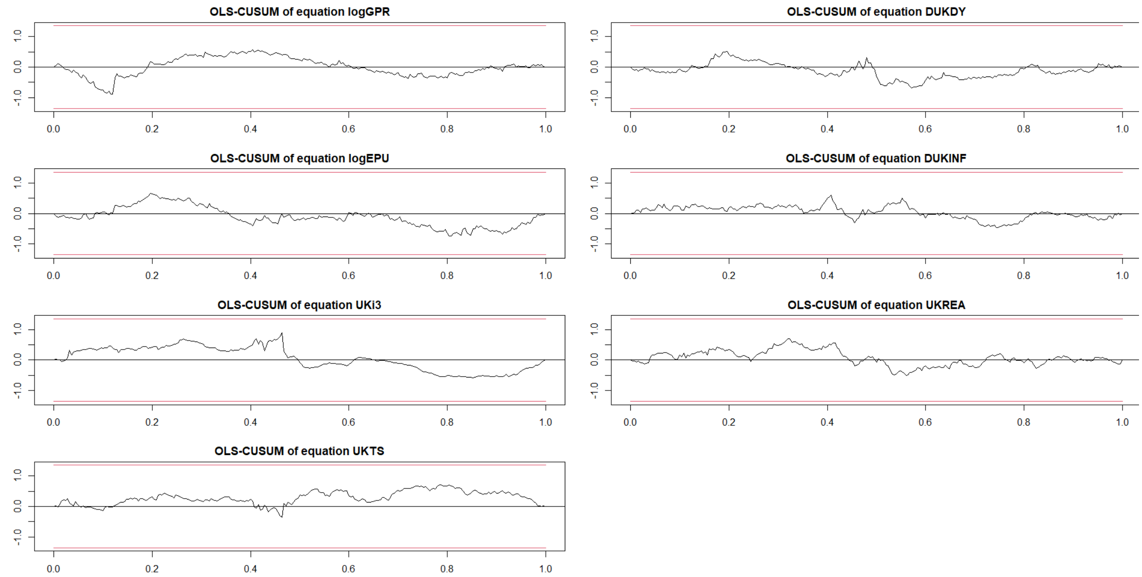
Panel A: Germany

	Statistics	Value
Model Stability		0.996, 0.938, 0.938, 0.896, 0.861, 0.755, 0.565, 0.329, 0.284, 0.284, 0.269, 0.269, 0.164, 0.164
Serial Correlation	1.768e-07	
Heteroscedasticity	1.000	
Normality of Residuals		
JB Test	< 2.2e-16	
Skewness	< 2.2e-16	
Kurtosis	< 2.2e-16	



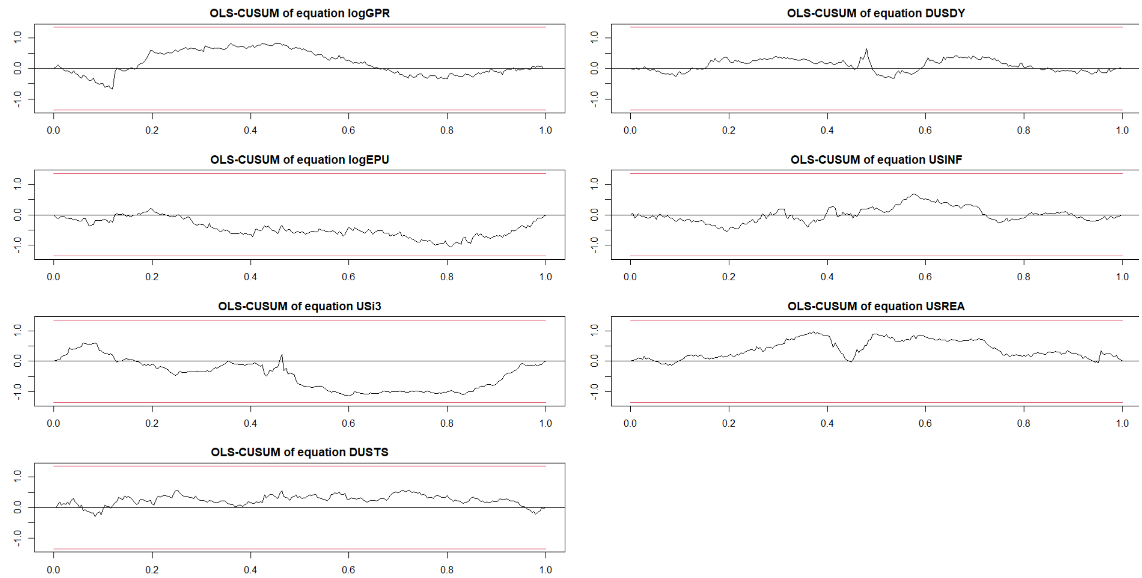
Panel B: The UK

	Statistics	Value
Model Stability		0.991, 0.957, 0.844, 0.830, 0.830, 0.472, 0.472, 0.453, 0.361, 0.321, 0.303, 0.284, 0.221, 0.044
Serial Correlation	2.385e-07	
Heteroscedasticity	1.000	
Normality of Residuals		
JB Test	< 2.2e-16	
Skewness	< 2.2e-16	
Kurtosis	< 2.2e-16	



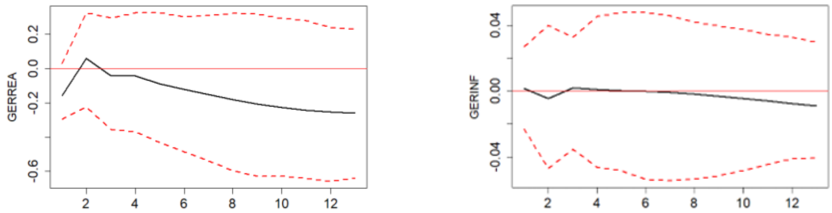
Panel C: The US

	Statistics	Value
Model Stability		0.948, 0.948, 0.902, 0.767, 0.767, 0.545, 0.545, 0.507, 0.507, 0.299, 0.299, 0.201, 0.128, 0.04
Serial Correlation	1.641e-07	
Heteroscedasticity	1.000	
Normality of Residuals		
JB Test	< 2.2e-16	
Skewness	< 2.2e-16	
Kurtosis	< 2.2e-16	

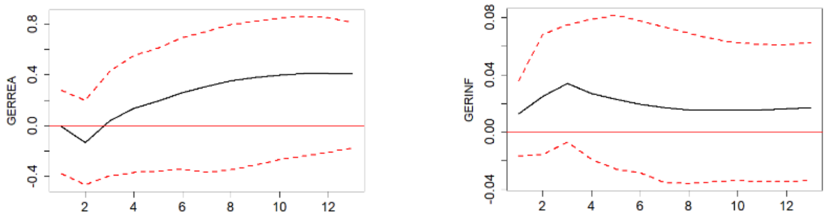


APPENDIX B. Impulse Response Functions

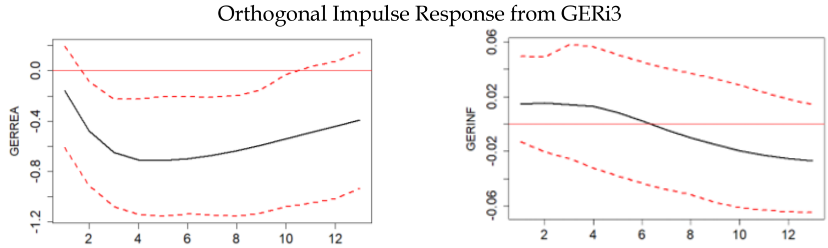
Orthogonal Impulse Response from logGPR



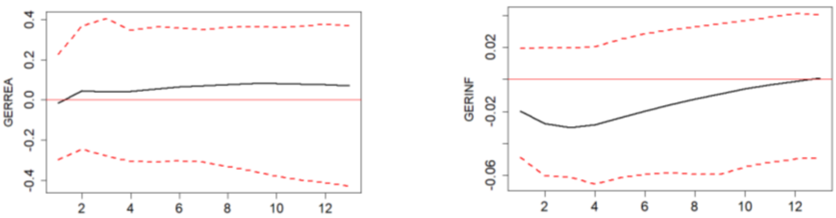
Orthogonal Impulse Response from logEPU



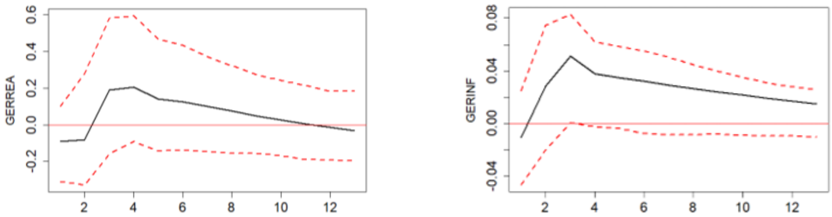
Orthogonal Impulse Response from GERi3



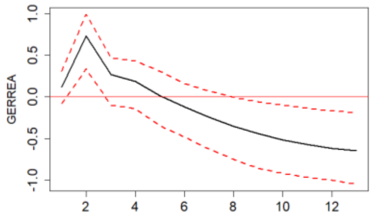
Orthogonal Impulse Response from GERTS



Orthogonal Impulse Response from DGERDY



Orthogonal Impulse Response from GERINF



Orthogonal Impulse Response from GERREA

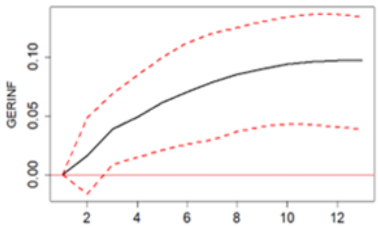


Figure B. 1. The impact of exogenous shocks in the German VAR (2) model on GERREA amd GERINF (impulse response functions, 95% bootstrap CI, 100 runs)

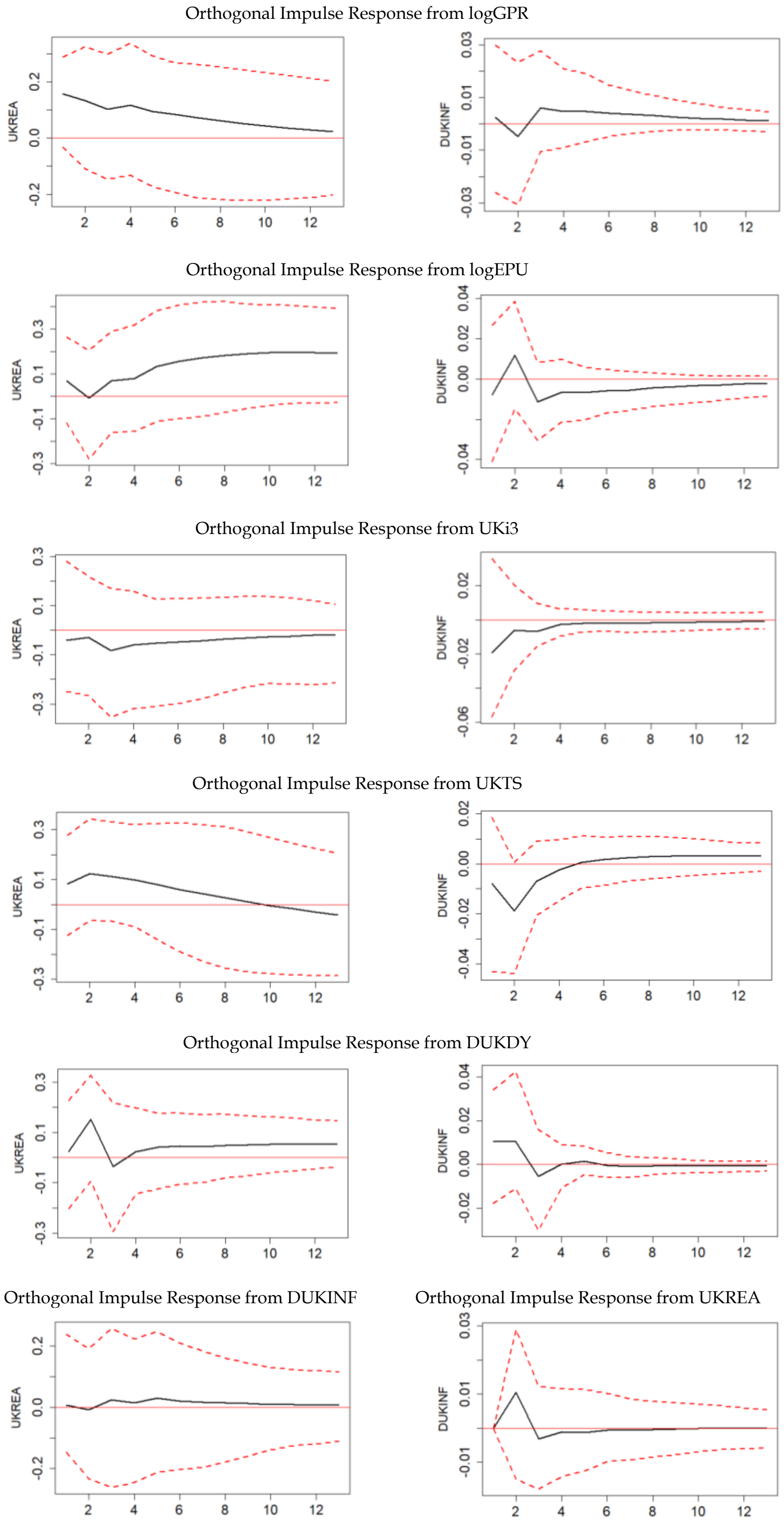


Figure B. 2. The impact of exogenous shocks in UK VAR (2) model on UKREA and DUKINF (impulse response functions, 95% bootstrap CI, 100 runs)

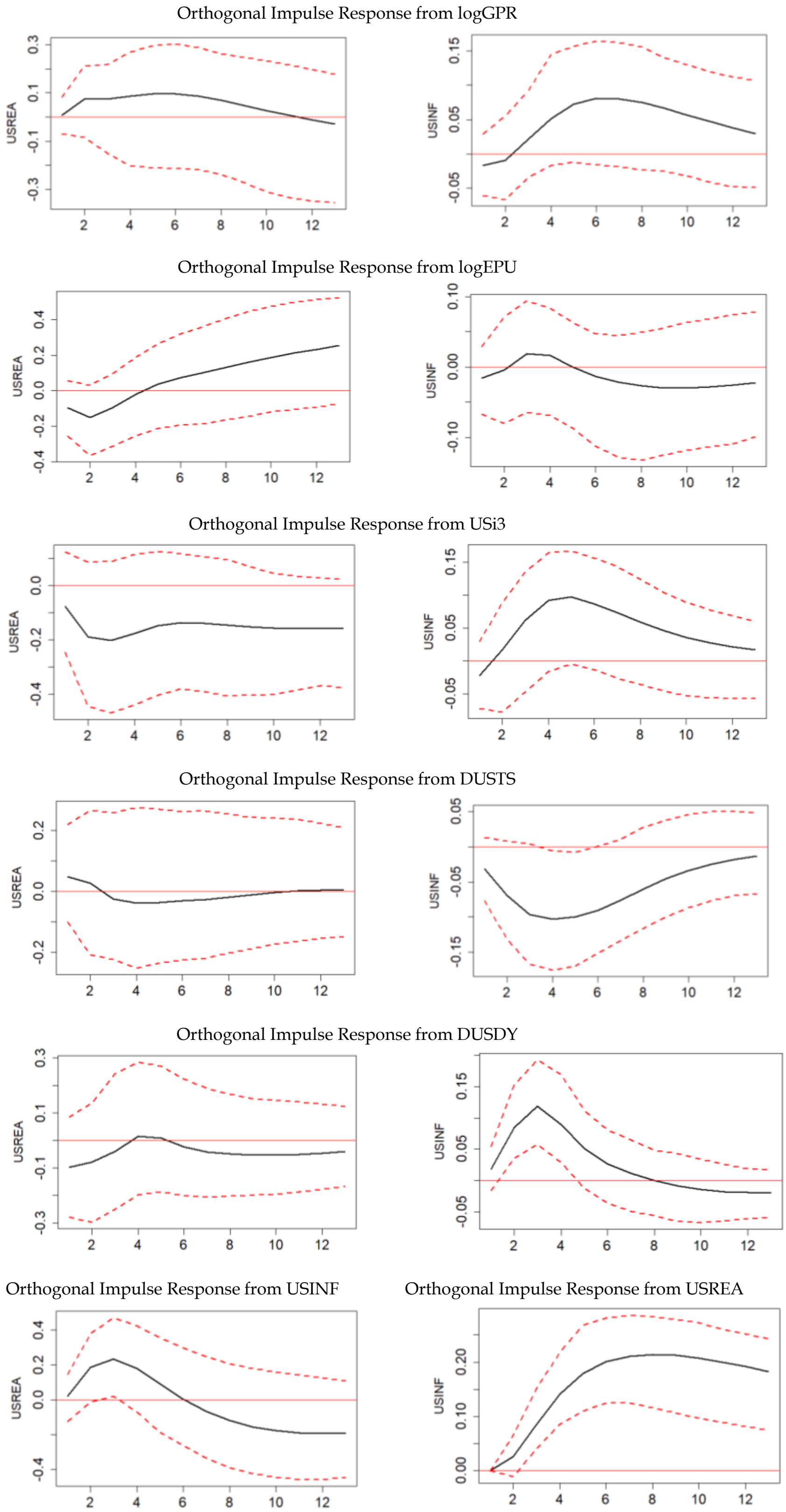


Figure B. 3. The impact of exogenous shocks in the US VAR (2) model on USREA and USINF (impulse response functions, 95% bootstrap CI, 100 runs)

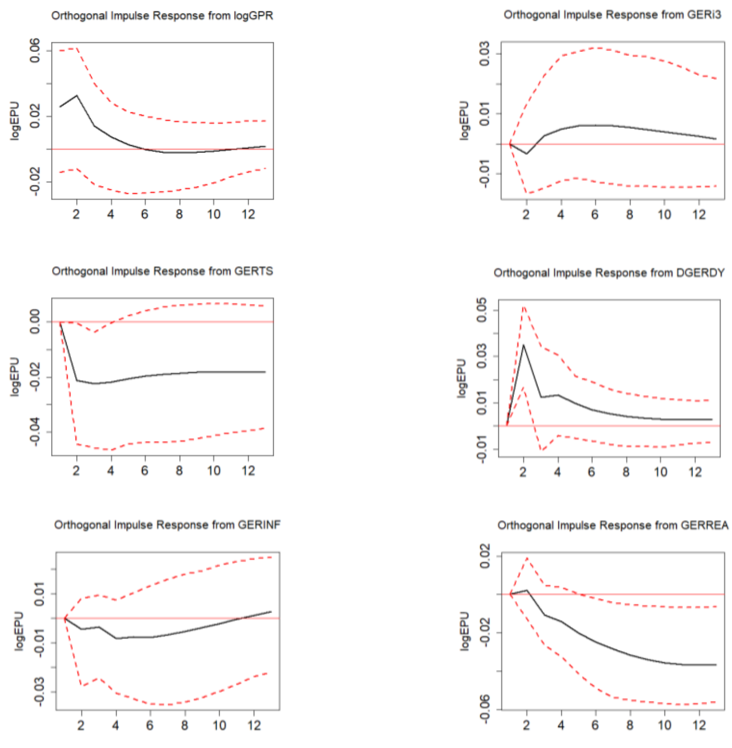


Figure B. 4. The impact of exogenous shocks in the German VAR (2) variables on logEPU (impulse response functions, 95% bootstrap CI, 100 runs)

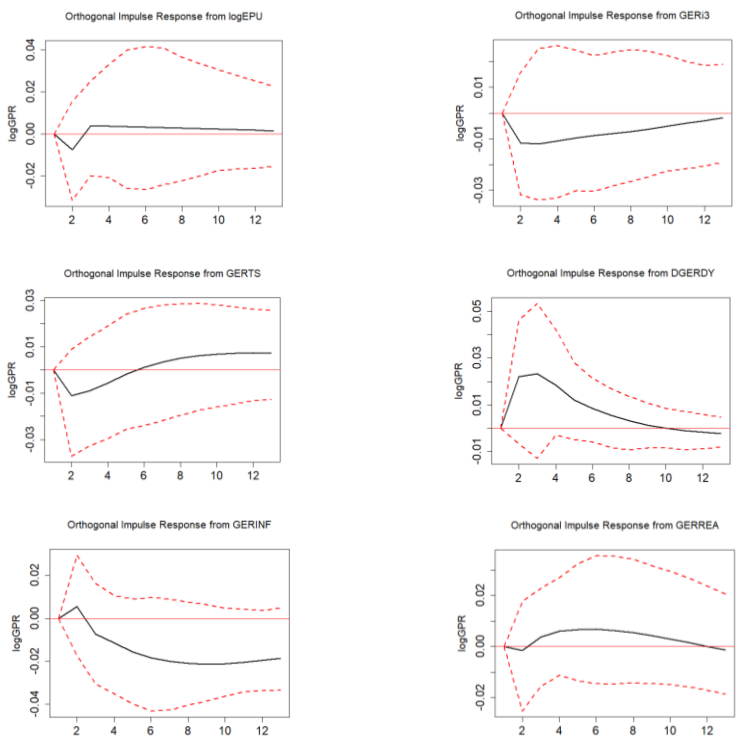


Figure B. 5. The impact of exogenous shocks in the German VAR (2) variables on logGPR (impulse response functions, 95% bootstrap CI, 100 runs)

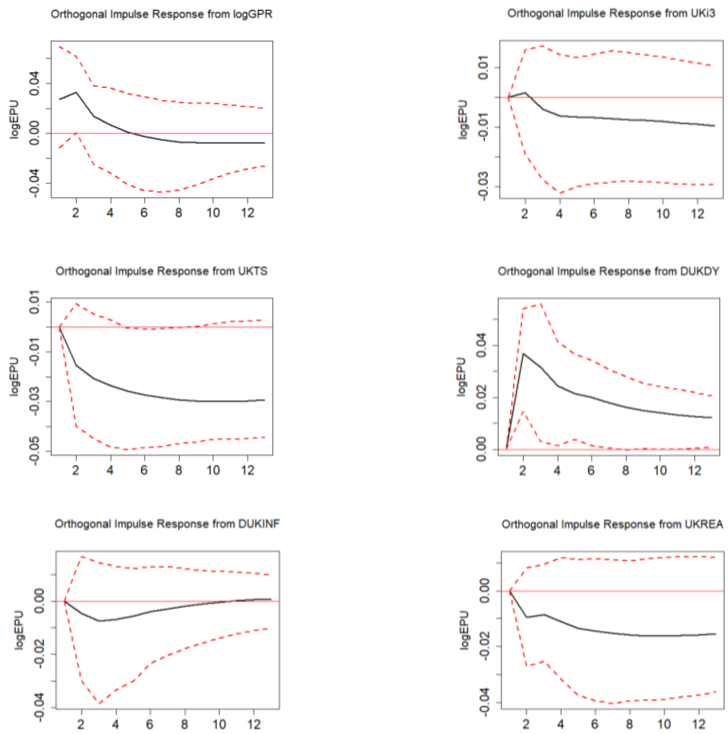


Figure B. 6. The impact of exogenous shocks in the UK VAR (2) variables on the economic policy uncertainty index (impulse response functions, 95% bootstrap CI, 100 runs)

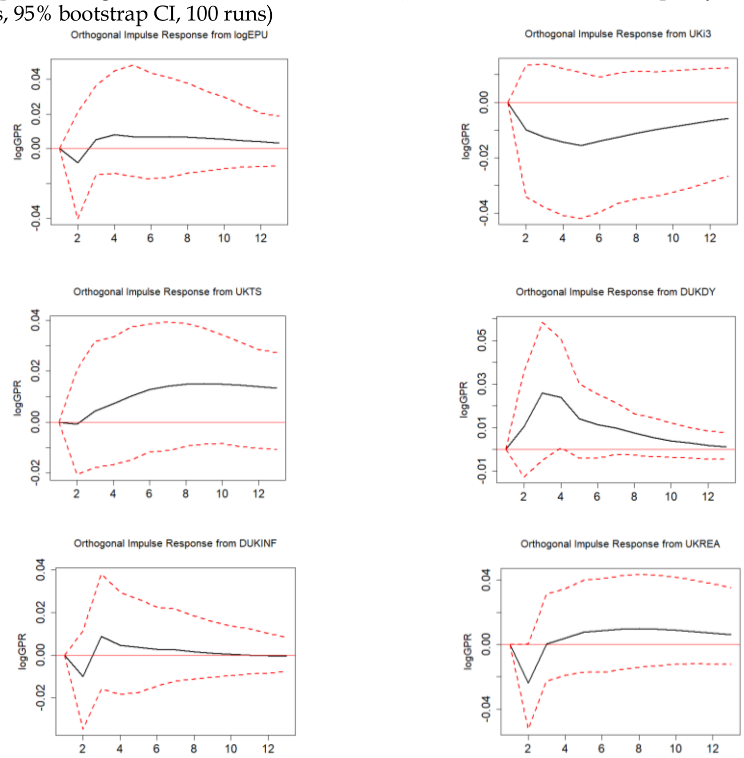


Figure B. 7. The impact of exogenous shocks in the UK VAR (2) variables on logGPR (impulse response functions, 95% bootstrap CI, 100 runs)

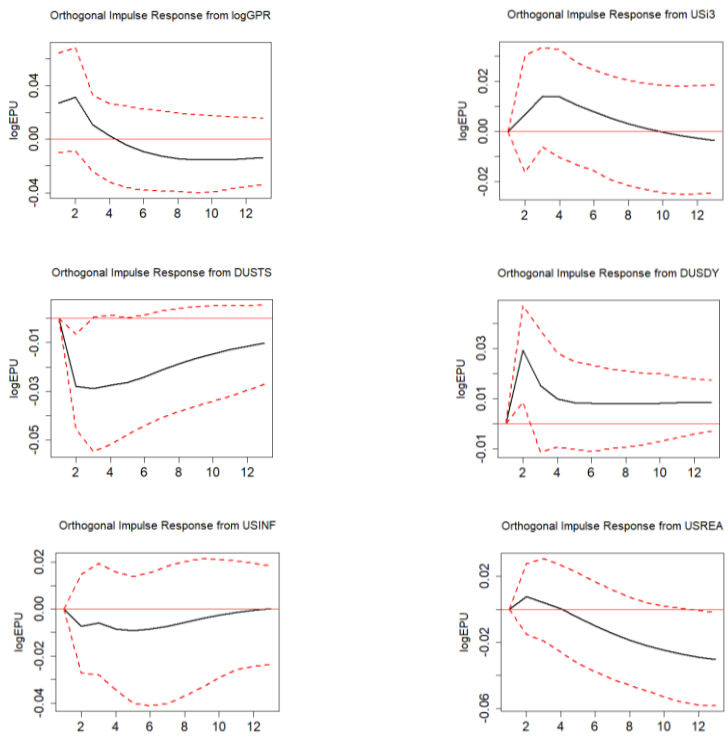


Figure B. 8. The impact of exogenous shocks in the US VAR (2) variables on the economic policy uncertainty index (impulse response functions, 95% bootstrap CI, 100 runs)

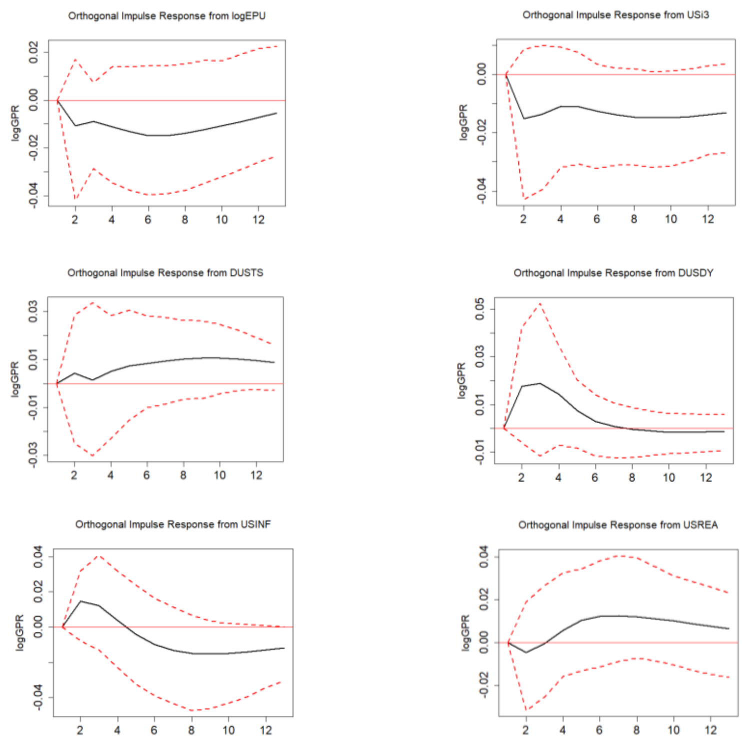


Figure B. 9. The impact of exogenous shocks in the US VAR (2) variables on logGPR (impulse response functions, 95% bootstrap CI, 100 runs)

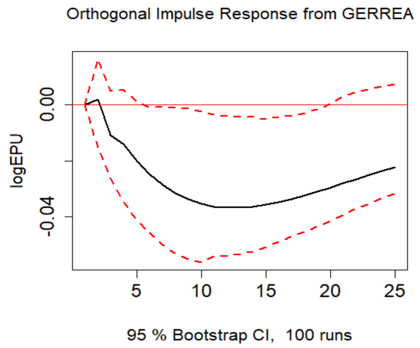


Figure B. 10. The impact of exogenous shocks in GERREA on logEPU, 24-periods ahead (impulse response functions, 95% bootstrap CI, 100 runs)

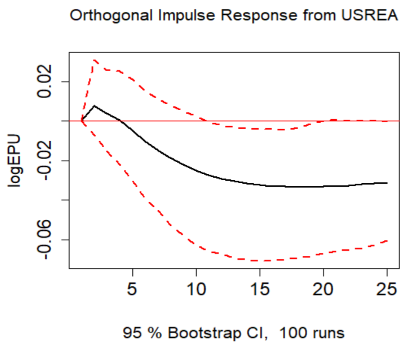
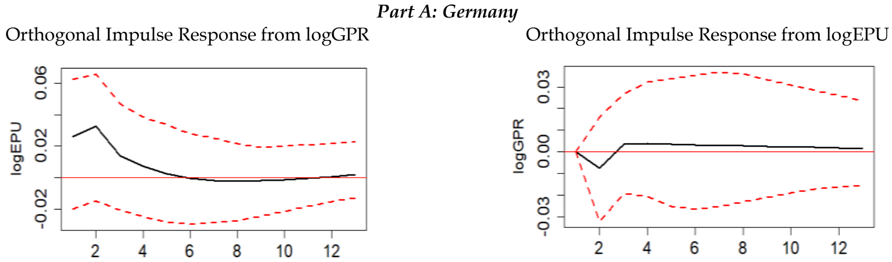
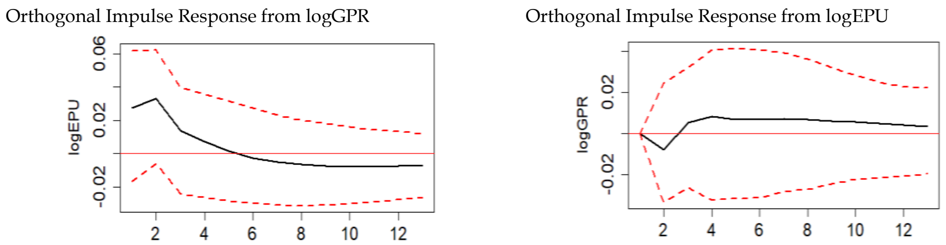


Figure B. 11. The impact of exogenous shocks in USREA on logEPU, 24-periods ahead (impulse response functions, 95% bootstrap CI, 100 runs)

Part A: Germany



Part B: The UK



Part C: The US

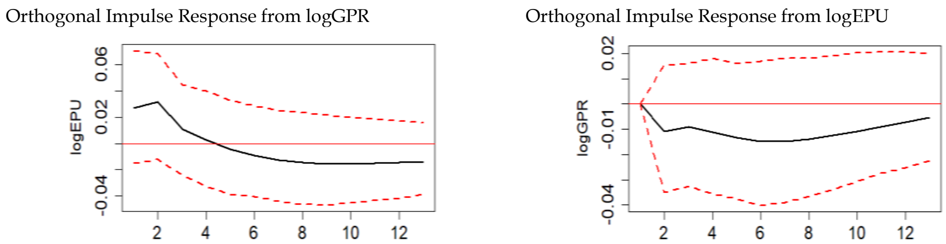


Figure B. 12. The impact of exogenous shocks in logGPR and logEPU on each other (impulse response functions, 95% bootstrap CI, 100 runs)

APPENDIX C. Forecast Error Variance Decompositions

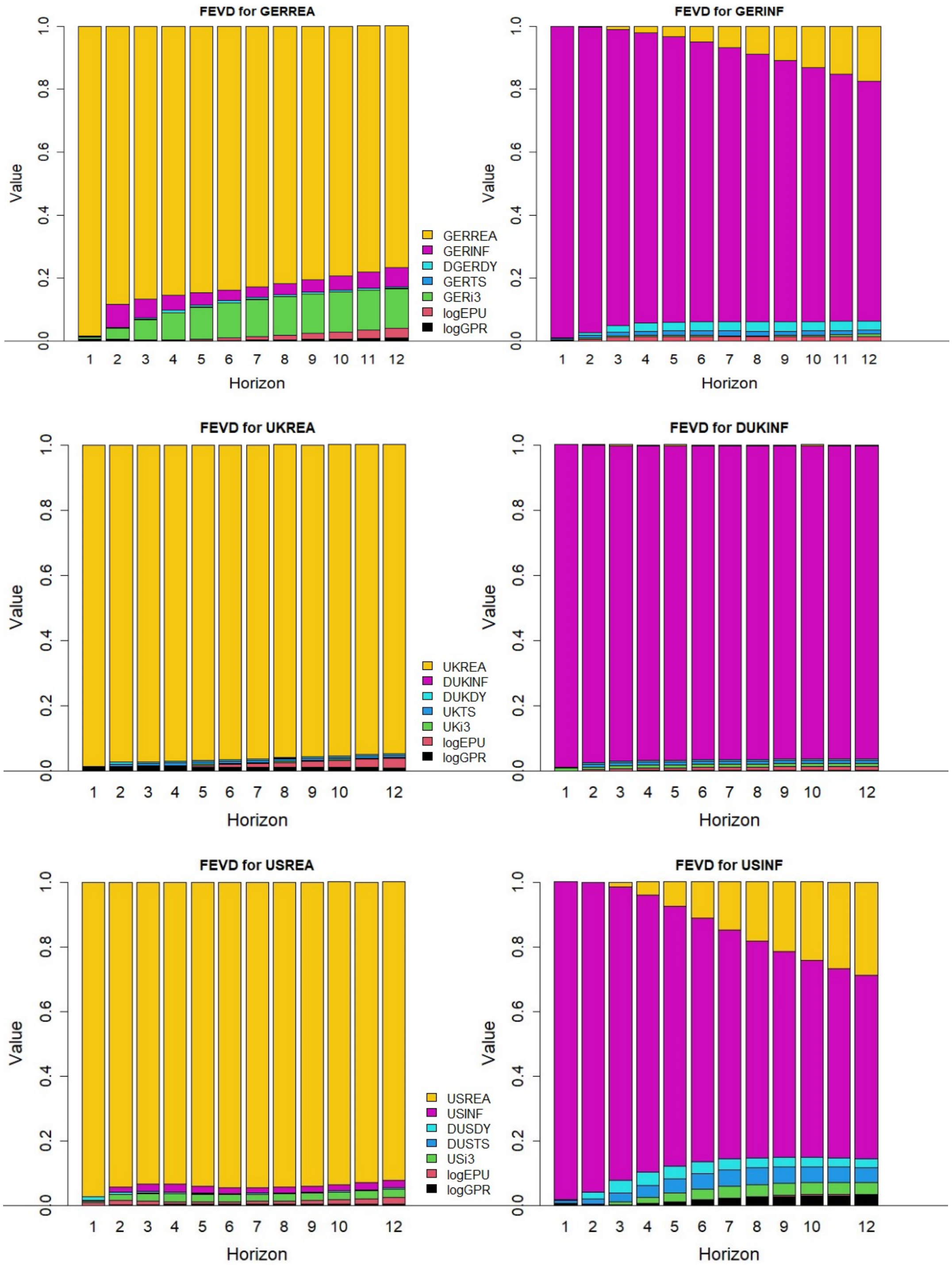


Figure C. 1. Forecast error variance decomposition for real economic activity and inflation in Germany, the UK, and the US.

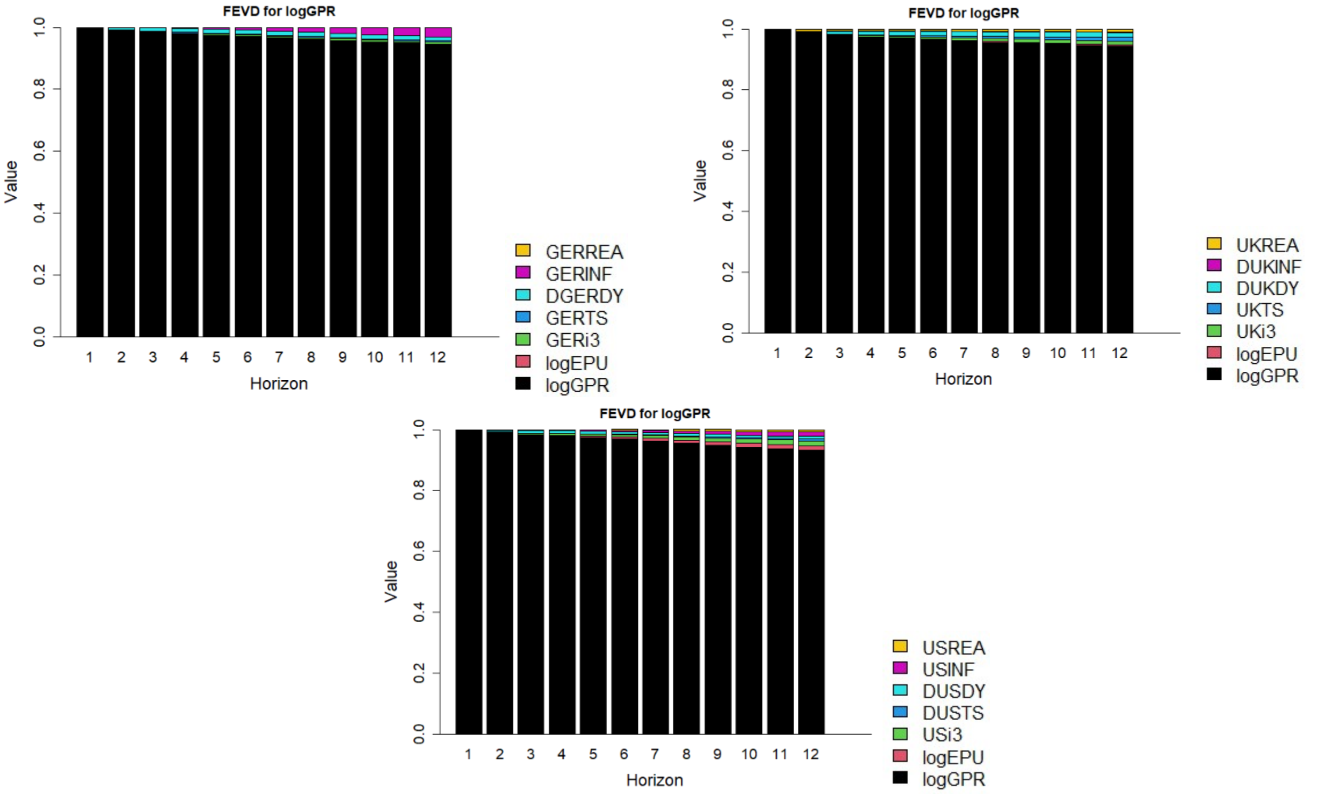


Figure C. 2. Forecast error variance decomposition for logGPR in context of Germany, the UK, and the US

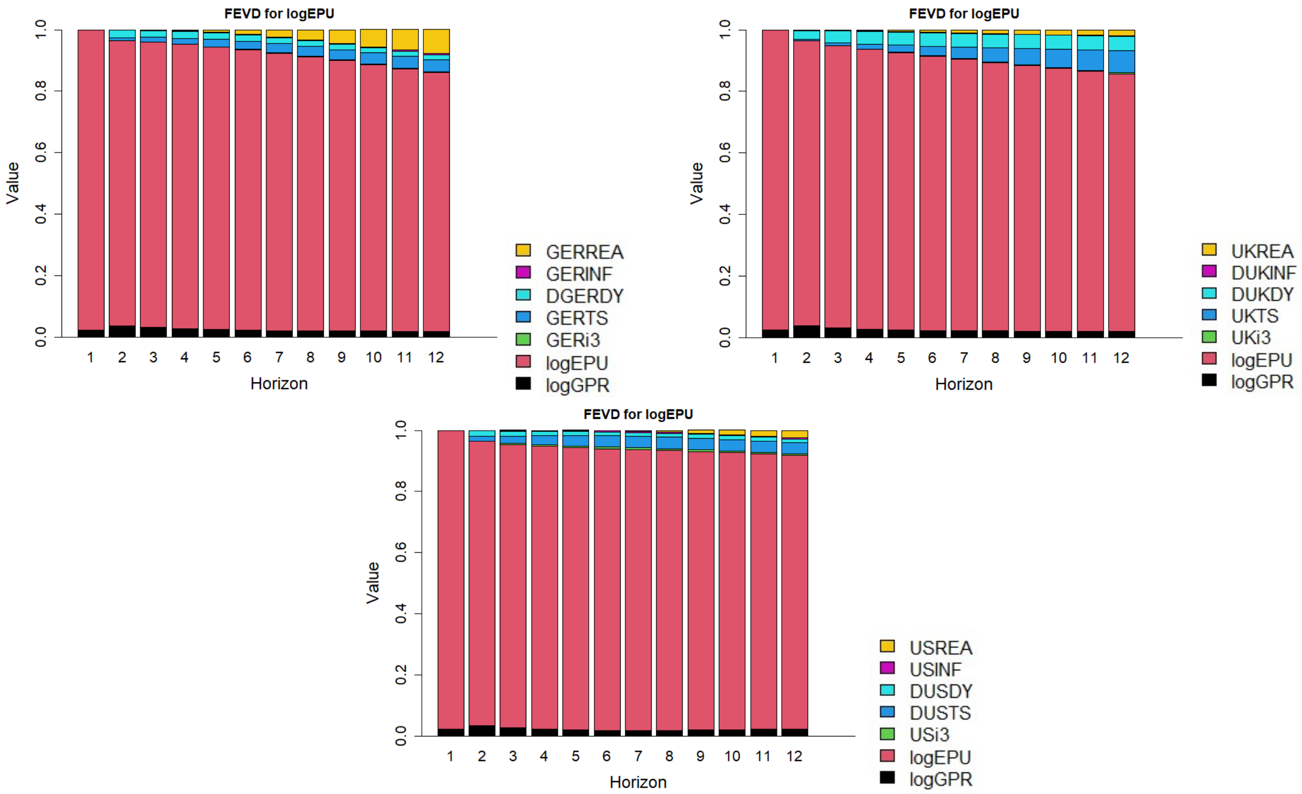


Figure C. 3. Forecast error variance decomposition for logEPU in context of Germany, the UK, and the US

APPENDIX D. THE USE OF AI

AI has been utilized to aid with the programming involved in RStudio for the data analysis part of this thesis. Particularly, ChatGPT 3.5 has been used to help generate commands for RStudio when the author's programming knowledge was not up to the mark. Asking ChatGPT about what I have asked its help for, the following response was generated:
"Based on our conversation, you mainly used my help to inquire about various aspects related to R programming and tasks related to your thesis or research work. This includes seeking assistance with creating and adjusting graphs in R, identifying the required packages in R for specific tasks, saving data in different objects in R, generating impulse response functions in R for your VAR analysis, obtaining forecasts of specific periods from a rollfore object in R[3], and extracting accuracy measures for specific variables within a VAR system in R. I have been assisting you by answering your questions, providing relevant code examples for RStudio, offering guidance on coding techniques, and helping you structure your code effectively."

[3] The author had named the object in R storing the forecasts as "rollfore" and had been referring to it as "a rollfore object" when mentioning it in ChatGPT 3.5 owing to which this particular phrasing was generated.