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Abstract

In this paper, we investigate the economic effects of geopolitical risk (GPR) shocks, with a focus on non-linear transmission mechanisms. Using a VARX framework, we show that larger positive shocks have a disproportionately greater impact, pointing to the existence of an amplification channel driven by rising uncertainty. Large GPR shocks trigger precautionary behaviours, leading to sharp declines in consumption and equity prices. In contrast, prices react positively but the responses are overall muted due to offsetting forces from reduced demand and heightened uncertainty. We further show that GPR shocks linked to anticipated geopolitical threats exhibit pronounced non-linearities, significantly increasing oil prices and inflation expectations, thereby exerting upward pressure on domestic prices.

Key words: Geopolitical risk, non-linearities, inflation, vector autoregressions, uncertainty.

JEL classification: C30, D80, E32, F44, H56.

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1 Introduction

In the aftermath of recent geopolitical tensions, such as Russia's invasion of Ukraine and renewed conflicts in the Middle East, heightened geopolitical risk (GPR) has emerged as a focal point in academic and policymaking debate. A growing body of literature underscores the consequential influence of geopolitical risk shocks on economic activity and inflation (Caldara and Iacoviello, 2022; Caldara et al., 2022). However, the precise scale of this influence, along with the mechanisms by which GPR shocks transmit through the economy, remains a subject of ongoing investigation.

For instance, the magnitude of these shocks, serving as a proxy for their economic significance, could be a key factor in determining their effects. Minor shocks may have relatively inconsequential outcomes due to the localized nature of events and limited global repercussions, suggesting that economies may not significantly deviate from their steady-state following such shocks. In contrast, large-scale shocks can have a larger and more significant impact on the global economy, also due to possible non-linear effects, leading to substantial and widespread economic disruptions. Additionally, comprehending the transmission channels of geopolitical risk shocks remains challenging due to their heterogeneous nature. This largely stems from the inherently diverse nature of geopolitical events, which can activate distinct economic transmission channels and yield heterogeneous impacts.

In this paper, we explore the non-linearities associated with the magnitude of shocks producing sudden increases in geopolitical risk. We test if positive geopolitical risk shocks produce significant non-linearities in the response of key real, nominal and financial variables, and we explore if accounting for non-linearities can help us reveal more clearly the main transmission channels of such shocks. We also study how variables react to two important sub-components of geopolitical risk, namely *Acts* and *Threats* - a distinction already introduced by Caldara and Iacoviello (2022). We analyse whether this can further help us understand how these shocks propagate through the economy, with a particular focus on their effects on different price components.

To our knowledge, all studies on geopolitical risk have relied on linear framework so far. Nevertheless, the literature on uncertainty (Caggiano et al., 2015, 2017b; Jackson et al., 2020; Chikhale, 2023), financial risk (Alessandri and Mumtaz, 2019; Candelon et al., 2021; Forni et al., 2023b), and news shocks (Forni et al., 2024) - which presents similar theoretical challenges to that of geopolitical risk - advocates for delving into non-linearities and state-contingent effects for a more comprehensive understanding of shock transmission[1]. This, along with the intrinsic global nature of many geopolitical events which could signal potential non-linearities as the size of positive shocks increases, suggests to test if non-linearities are an important factor that could amplify the overall impact also in the presence of geopolitical risk shocks.

Our analysis also aims to clarify the primary transmission mechanisms through which GPR shocks impact the economy — an area of increasing importance for policy institutions and academic research. The literature has suggested that such shocks can influence the economy through direct and tangible impacts, similar to disaster events, such as wars that impair infrastructure or industrial capacity (Barro and Ursúa, 2012), but may also depress demand or even stimulate output through increased military spending (Ramey, 2011). These shocks may also transmit via an increase in volatility and uncertainty, potentially leading to precautionary behaviors of that can defer consumption and investment decisions.[2] The impact on inflation remains even less clear and poorly studied, despite a large increase in interest in this topic following the recent episodes in the post-pandemic era.[3]

More in detail, our empirical approach follows a two-step strategy. Building on the work of Caldara and Iacoviello (2022), who construct a measure of adverse geopolitical events and risks, in a first step we estimate a GPR shock in a structural vector autoregressive (SVAR) model where we include real, nominal, and financial variables. We then follow the methodology proposed by Forni et al. (2023b), who suggest a flexible way to estimate a vector moving average representation of the structural model containing the estimated shocks and their non-linear functions to retrieve the overall non-linear transmission mechanism. More precisely, in this paper we use the linear geopolitical risk shock estimated in the first step and its quadratic transformation.

To analyse the decomposition of geopolitical risk into *Acts* and *Threats*, we follow a similar empirical strategy as the one used for our baseline application, the only difference being that we identify contemporaneously the effect of two shocks and

[1]Non-linearities have been extensively studied also in the context of other shocks such as monetary policy (Barnichon and Matthes, 2015; Debortoli et al., 2020; Ascari and Haber, 2021), government spending (Caggiano et al., 2017a; Mumtaz and Sunder-Plassmann, 2021; Barnichon et al., 2022) or oil supply news Forni et al. (2023a).

[2]See also ECB (2024) for a detailed discussion on the channels through which geopolitical risk can affect the economy.

[3]Moreover, there are different opinions on how *generic* uncertainty shocks affect prices. For instance, Mumtaz and Theodoridis (2018) find inflationary effects following uncertainty shocks for the US post WWII, Alessandri and Mumtaz (2019) find deflationary effects in a financial crisis but normally inflationary effects, Haque and Magnusson (2021) find uncertainty shocks to be deflationary and De Santis and Van der Veken (2022) highlight that financial uncertainty shocks are inflationary while broader uncertainty shocks are deflationary.

their non-linear transformation. Specifically, we study the effects of these shocks on inflation through a model similar to the one used for the GPR shock but augmented by different price components.

Our findings point to significant non-linearities as GPR shocks' size increases, with the non-linear component significantly influencing the response of variables to these shocks. Thus, relying solely on linear models may lead to an underestimation of the overall impact. This conclusion is supported by both impulse response and historical decomposition analyses. The historical decomposition, in particular, highlights the crucial role of non-linear shocks in explaining the movements of real and nominal variables during major geopolitical events, such as in the aftermath of 9/11, during the Iraq War, and to some extent, Russia's invasion of Ukraine.

Accounting for non-linearities also helps to shed light on the propagation mechanism of GPR shocks by revealing a predominant channel: large geopolitical shocks are associated with heightened uncertainty, and trigger precautionary and wait-and-see behaviors of households and firms. This channel causes a significant decline in equity prices and private consumption and amplifies the overall impact of the shocks, but becomes active only in the case of substantially large shocks while remaining generally muted with smaller shocks. These findings help explain why asymmetries in magnitude occur with large geopolitical shocks and clarify the interaction between these shocks and the more standard uncertainty channel.

Finally, we find that the effect of GPR shocks on prices is overall positive but subdued compared to other variables, with also rather limited non-linearities. We show that this is caused by the counteracting effects of the two subcomponents of GPR shocks. While *Act* shocks exert a negative response in real oil prices, CPI, inflation expectation measures and activity, reflecting dampened aggregate demand, *Threats* shocks lead to significant price increases. This is mainly due to an increase in the speculative demand for oil, although results can also be explained by a change in firms' pricing behavior under periods of uncertainty.

Such decomposition suggests that GPR *Act* shocks are likely to be conceptually closer to first-moment negative demand shocks, while *Threats* are closer to second-moment positive uncertainty shocks. On this, we show that *Threats* shocks are particularly subject to non-linearities as size increases. These non-linearities are very marked in oil prices and inflation expectations, which in turn cause a substantial increase in both CPI and core inflation.

Apart from the aforementioned papers, our work is related to a growing body of literature studying the effects of geopolitical risk shocks. Pinchetti (2024) explores how geopolitical tensions affect energy markets, focusing on oil prices and supply dynamics. He proposes a way to disentangle geopolitical risk shocks acting through demand and those acting through the supply of oil. Jalloul and Miescu (2023) examine how geopolitical risk influences the interconnectedness of G7 equity returns, particularly driven by perceived threats. Drobetz et al. (2021) investigate the effects of geopolitical risk on shipping freight rates, revealing its significant impact on global trade. Franconi (2024) demonstrates how monetary policy efficacy is influenced by geopolitical risk levels, affecting inflation and economic stability. Francis et al. (2019) identifies geopolitical uncertainty as a primary driver of international business cycle comovement. Nguyen and Thuy (2023) analyse the association between geopolitical risk and bank loan costs, showcasing its influence on financial markets and lending practices.

The remainder of the paper proceeds as follows: Section 2 presents the methodology, Section 3 presents our empirical exercise, and Section 5 concludes.

2 Econometric Approach

We use the econometric approach proposed in Forni et al. (2023b) to study non-linearities in the effects of a geopolitical risk shock. In this section we report and discuss the main features of the methodology.

2.1 Non-linear Representation

Let x_t be a n-dimensional stationary vector of macroeconomic variables with the following structural representation

$$x_t = \nu + \beta(L)g(u_{gt}) + \Gamma(L)u_t \tag{1}$$

where ν is a vector of constants, u_{gt} is the geopolitical risk shock (the g-th element of the n-dimensional vector u_t and $g(u_{gt})$ is a non-linear function of the shock. The vector u_t contains all the structural shocks that are assumed to be serially and mutually independent with zero mean and unit variance. $\Gamma(L)$ is an $n \times n$ matrix of impulse response functions. Equation (1) can be rewritten as

$$x_t \;\; = \;\; \nu + \beta(L)g(u_{gt}) + \alpha(L)u_{gt} + \Gamma_{-g}(L)u_{-gt} \tag{2}$$

where $\alpha(L)$ is the g-th column of $\Gamma(L)$, u_{-gt} is a vector containing all the structural shocks except the geopolitical risk shock and $\Gamma_{-g}(L)$ is the corresponding matrix of impulse response functions. Notice that equation (2) is a Vector Moving Average (VMA), augmented with a non-linear function of the shock of interest. In our application we use $g(u_{gt}) = (u_{gt})^2$.[4]

The non-linear impulse response functions are derived by combining the two terms $\alpha(L)$ and $\beta(L)$. More specifically, the total effects of a geopolitical risk shock $u_{gt} = u^*$ are given by the sum of the linear and non-linear terms:[5]

$$IRF(u_{gt} = \bar{u}^*) = \alpha(L)u^* + \beta(L)g(u^*) \tag{3}$$

For instance when $g(u_{gt}) = (u_{gt})^2$, the responses to a unitary shock are

$$IRF(u_{gt} = 1) = \alpha(L) + \beta(L), \quad IRF(u_{gt} = -1) = -\alpha(L) + \beta(L). \tag{4}$$

and for a two-standard deviation shock are

$$IRF(u_{gt} = 2) = \alpha(L)2 + \beta(L)4, \quad IRF(u_{gt} = -1) = -\alpha(L)2 + \beta(L)4. \tag{5}$$

Notice that, as evident from equation (5), both sign and size asymmetry can arise in the quadratic case. Of course, if non-linearities are not important $\beta(L) = 0$, then the responses coincide with those of a linear VMA.

2.2 Identification and Estimation

Under the assumptions discussed in Forni et al. (2023b),[6] vector x_t in equation (1) admits the following representation:

$$A(L)x_t = \mu + \tilde{\beta}(L)g(u_{gt}) + \Gamma_0 u_t, \tag{6}$$

[4]Notice that the serial and mutual independence assumption implies that all structural shocks, including u_{gt}, are uncorrelated with the lags of $g(u_{gt})$ and x_t. Notice also that u_{-gt} could also include non-linear functions of other shocks.

[5]The total responses defined in equation (3) simply correspond, in this non-linear context, to the Generalized Impulse Response Functions defined as $E(x_{t+h}|u^g_{gt} = u^*) - E(x_{t+h}|u_{gt} = 0)$, $h = 0, 1, \ldots$.

[6]Assumptions are that the impulse response functions can be further parameterized as follows: $\beta(L) = A(L)^{-1}\tilde{\beta}(L)$ and $\Gamma(L) = A(L)^{-1}\Gamma_0$, with $A(L)$ which is a $n \times n$ matrix of finite order polynomials in L such that $A(0) = I_n$, and $\Gamma_0 = \Gamma(0)$ is a matrix of constant with the property that the elements on the main diagonal of Γ_0^{-1} are equal to one, and $\tilde{\beta}(L)$ is a vector of polynomials in L.

where $\mu = A(1)\nu$, $A(L) = I_n - A_1 L - \cdots - A_p L^p = (I_n - \tilde{A}(L))$ is a matrix of polynomials of degree p, $\tilde{\beta}(L) = A(L)\beta(L)$ and $\Gamma_0 = A(L)\Gamma(L)$. Model (6) is a VARX where the shock of interest and its non-linear functions are the exogenous variables. We assume for simplicity, as in Forni et al. (2023b), that no lags of $g(u_{gt})$ enter equation (6), i.e. $A(L)\beta(L) = \tilde{\beta}_0$, thus the model can be expressed as:

$$x_t = \mu + \tilde{A}(L)x_t + \tilde{\beta}_0 g(u_{gt}) + \alpha_0 u_{gt} + \Gamma_{-g0} u_{-gt} \tag{7}$$

Direct estimation of the VARX is not feasible since the exogenous variables are not observable. Thus, the shock needs to be estimated outside the model to estimate the impulse response functions in equation (7).

We identify the geopolitical risk shock exactly as in Caldara and Iacoviello (2022). The shock is obtained as the first shock in the Cholesky representation of x_t with the geopolitical risk index ordered first.[7] In practice, the shock is obtained as the difference between the geopolitical risk index and the projection of this variable onto p lags of itself and the remaining variables included in x_t. In our setting, this restrictions implies that the gth row of Γ_{-g0} is zero (same restrictions imposed in Caldara and Iacoviello (2022)) and that the gth element of $\tilde{\beta}_0$ is zero (new restrictions required in our setting). The last restriction can be tested and we will discuss the results of the test in the empirical application. Once an estimate of the shock is available, the VARX can be estimated using OLS.

3 Empirical Application

Our empirical analysis focuses on the potential non-linear effects caused by geopolitical risk shocks following the methodology explained in Section 2.

3.1 Data and Bayesian Estimation

We use monthly U.S. data comprising the following variables: the Geopolitical Risk Index, the CBOE Volatility index (VIX), the S&P500 stock market index, Industrial Production, the Consumer Price Index (CPI), Real Consumption Expenditure, and the Federal Funds Rate.[8] We work with stationary data and we take the log-difference

[7] The existence of a VAR representation for x_t is guaranteed by the existence of the Wold representation, by stationarity of x_t together with the assumption of invertibility of the Wold representation. If the variables are cointegrated such a VAR will exist for the variables in levels.

[8] We complement the Fed Funds Rate with the measure of shadow rate proposed by Wu and Xia (2016) from 2000M1 to 2023M6.

transformation of all the real and nominal variables and the first difference for the policy rate, while the VIX enters the model in levels. The GPR series is instead transformed into log-levels as in Caldara and Iacoviello (2022). The sample spans from January 1970 to December 2023. Table A2 in Appendix A provides a detailed description of the data, including their sources and the applied transformations.

We estimate the model with bayesian shrinkage techniques by applying a minnesota-type prior. For consistency, this is done for both the SVAR (first step) and the VARX (second step). More precisely, for the SVAR in the first step, we assume that each series follows an AR(1) process by setting a prior of 0.9 for the reduced-form coefficient on its own first lag and zero for the remaining lags.[9][10] In the VARX, we assume the same priors on the reduced-form coefficients of the matrix $\tilde{A}(L)$ plus diffuse priors for the coefficients of the exogenous variables $\tilde{\beta}_0$ and α_0.

We also estimate different specifications as robustness exercises. For instance, we run robustness checks on the Covid-19 period by including dummies over this period as described by Cascaldi-Garcia (2022). Moreover, following Bergholt et al. (2023), we also estimate an alternative model specification where we include the dummy-initial-observation prior to shrink the uncertainty around the deterministic component, which could be an important factor affecting the historical decomposition. Finally, bayesian shrinkage permits to easily deal with the choice of the p-lag order, which is set to 12.

3.2 The Geopolitical Risk Shock

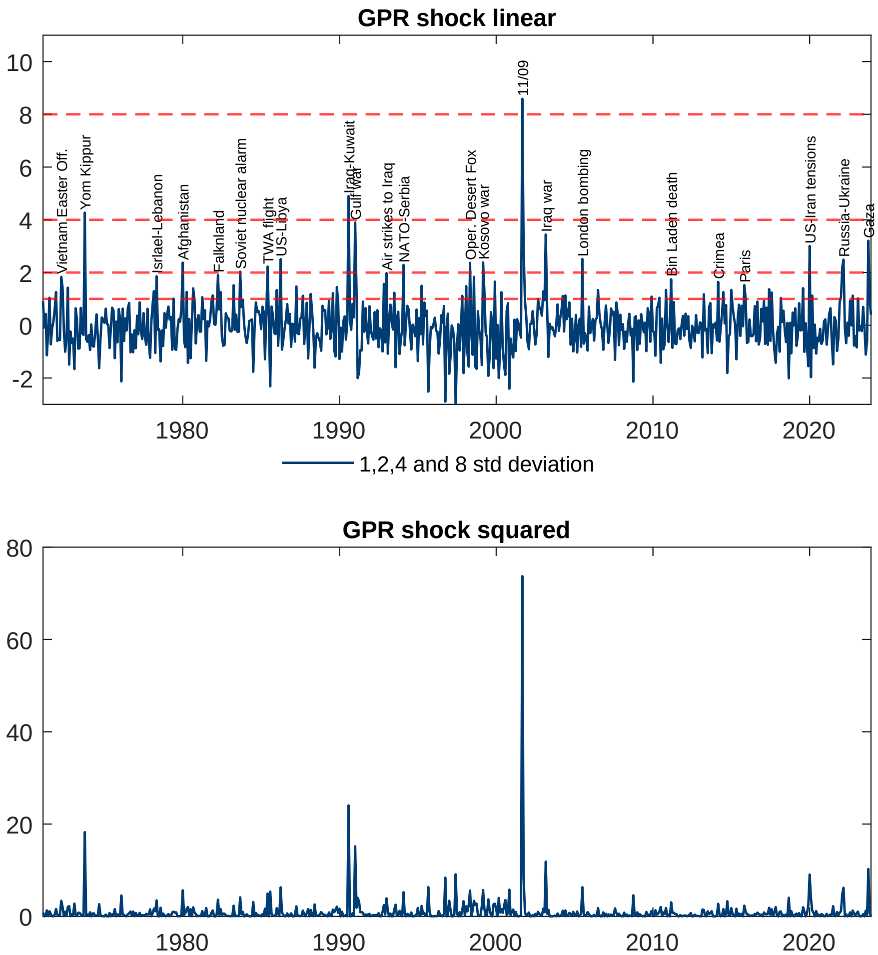
As explained in Section 3, we first identify the geopolitical risk shock as in Caldara and Iacoviello (2022). We then test the identifying assumption that the gth element of $\tilde{\beta}_0$ is equal to zero using a t-test in the regression of the GPR index onto both the shock, its square, and p lags of all the variables. The p-value obtained is 0.725 suggesting that the non-linear term is not a significant regressor, thus our assumption holds in the data.

The top panel of Figure 1 illustrates the geopolitical risk shock identified from the linear SVAR, with horizontal red dotted lines marking 1, 2, 4, and 8 standard

[9] This choice is dictated by the fact that we are working with stationary data. This helps us shrink the volatility around the deterministic component when dealing with the historical decomposition. Nevertheless, this choice does not affect the results as shown in Section **??**, with presents robust results also with the specification in levels.

[10] Bayesian estimation is implemented via hierarchical priors as in Giannone et al. (2015). We set the initial value of the overall tightness of the prior λ to 0.3, while the lag decay parameter α is set to 2.

Figure 1. The Estimated Geopolitical Risk Shock and its square



Notes: Geopolitical shock estimated in the linear SVAR model (top panel) along with its quadratic transformation (bottom panel). The shock reflects the median series of the overall posterior shocks' distribution. Positive values of the shock correspond to an increase in Geopolitical Risk. The red dashed lines in the top panel show 1, 2, 4 and 8 standard deviations respectively. Labels refer to particularly large geopolitical events and are described more extensively in table A1 in Appendix A.

deviation thresholds, while the bottom panel portrays its non-linear quadratic transformation. Several observations emerge from an initial visual inspection. First, the shock displays notable positive surges, particularly on certain occasions. Across the analysed sample, the series surpasses two standard deviations in eighteen episodes. Among these occurrences, four instances stand out where the shock exceeds or equals four standard deviations: during the Yom Kippur War in 1973, amid the Gulf War in the early nineties, and during the periods encompassing 9/11 and the subsequent Iraq war. As anticipated, the shock demonstrates a pronounced spike during the 9/11 terrorist attacks, resulting in an increase of 8 standard deviations in the geopolitical risk index.

In general, the shock exhibits a pronounced right-skewness, with only a few instances displaying pronounced negative values. This observation is unsurprising and is an intrinsic characteristic of the text-based index developed by Caldara and Iacoviello (2022), which by construction only detects increases in geopolitical risk.[11] This one-sided nature is reflected in our estimated underlying shock and is important in our analysis and the selection of non-linearities examined in our study. Indeed, the literature on non-linearities typically contrasts the varied impacts of positive and negative shocks on the economy, as exemplified by Forni et al. (2023b); Debortoli et al. (2020). However, the scarcity of substantial negative geopolitical risk shocks, and the lack of their economic interpretation, underscores the necessity to focus on the non-linearities associated with the magnitude of positive shocks only.

Nevertheless, as noted by Caravello and Martinez-Bruera (2024), applying a quadratic non-linear transformation alone does not adequately disentangle sign and size non-linearities in the presence of asymmetric shocks. This limitation is less relevant in our analysis since the index employed specifically captures one-sided events — more precisely, increases in adverse geopolitical risk — based on the frequency of specific terms in leading U.S. newspapers. This design inherently limits the scope for examining *sign* non-linearities. Consequently, the use of a quadratic transformation is appropriate for capturing the effect of non-linearities, as our analysis is inherently focused on the impact of *positive* large shocks.[12]

Although the primary aim of this initial step is exclusively the estimation of the shock, in this section we also present the resulting IRFs. Notice that under the null that $\beta(L) \neq 0$, the estimated responses cannot be correct. Nonetheless, these IRFs are a useful benchmark for the results obtained using the non-linear model specification in the following section.

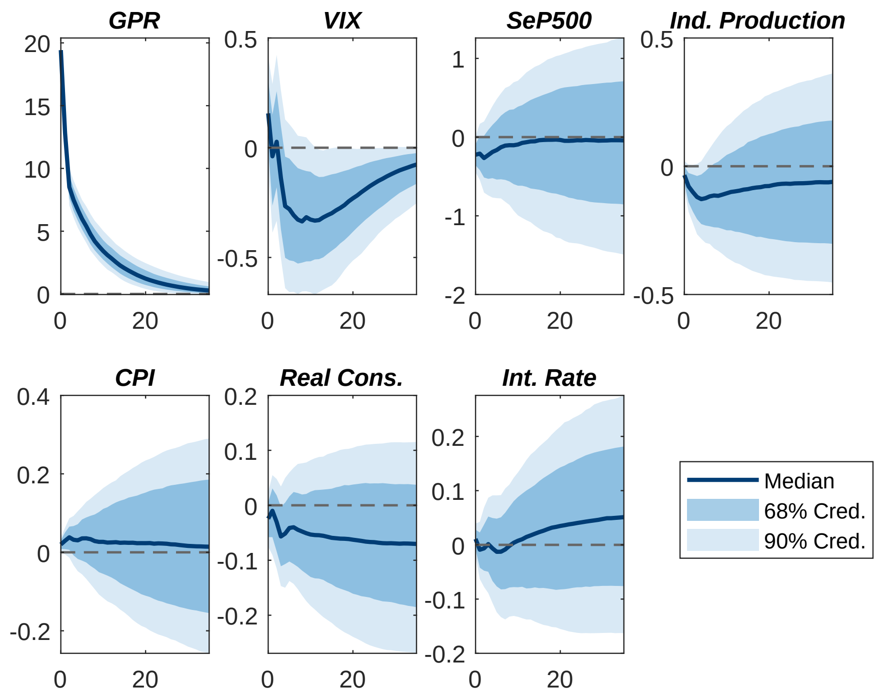
Figure 2 depicts the IRFs to the one standard deviation linear shock shown in Figure 1 (top panel). Responses for the real and nominal variables are cumulated to show the overall effects on the log-levels. The solid blue line represents the median response, while the shaded areas denote the 68% and 90% credible intervals. The x-axis denotes the months following the shock, spanning up to 36 months (3 years). The

[11] Figure B1 compares the GPR index and the linear shock estimated in the SVAR.

[12] Nevertheless, in the robustness Section 3.6 we analyse the results derived from an alternative specification where we use the cubic instead than the quadratic transformation, which Caravello and Martinez-Bruera (2024) claim is better tailored to study size-only non-linearities.

results resemble those reported in Caldara and Iacoviello (2022) and are consistent with findings presented in Caldara et al. (2022).[13]

Figure 2. The Impact of GPR shock in the linear SVAR



Notes: The solid blue line represents the median response to a GPR shock identified in the linear SVAR, while the shaded bands the 68% and 90% credible intervals. All variables in percent, except for the FED shadow rate in percentage points and the VIX in points.

A one standard deviation shock to geopolitical risk - corresponding to an increase of the geopolitical risk index by around 20 percent[14] - has a non-significant and short-lived positive impact on uncertainty, as shown by a relatively muted response of the VIX, which declines after the initial increase and stays negative over the horizon considered. Industrial production and real consumption both marginally decline at impact, with the response of the latter being less statistically significant than that of the former. Stock prices also decline at impact, though the overall effect is relatively contained in magnitude. The shock also exerts a positive effect on prices which increase mildly but the response is statistically significant only in the first two months. The Fed funds rate is unchanged over the first months before increasing thereafter,

[13] It is noteworthy, however, that Caldara and Iacoviello (2022) estimate a model with quarterly data. Nonetheless, the responses from our monthly specification align with those obtained in the aforementioned study.

[14] In our sample, we find a total of 73 episodes exceeding a one standard deviation shock. Those episodes can be visualised in Figure 1

but its response is also rather insignificant. Overall, our results seem to confirm that (i) a geopolitical shock has an overall negative but rather marginal impact on the economy, (ii) that uncertainty does not appear to be a key transmission channel, as shown by the relatively muted response of the VIX and (iii) that the effect of the shock on prices is neither clearly positive nor negative.

In the subsequent section, we extend our analysis to incorporate the non-linear quadratic transformation of the GPR shock. This expansion enables a comparison between the responses of the linear and non-linear shocks, providing insights into whether the overall results diverge from the IRFs estimated in the linear model.

3.3 Disentangling the Role of Non-linearities

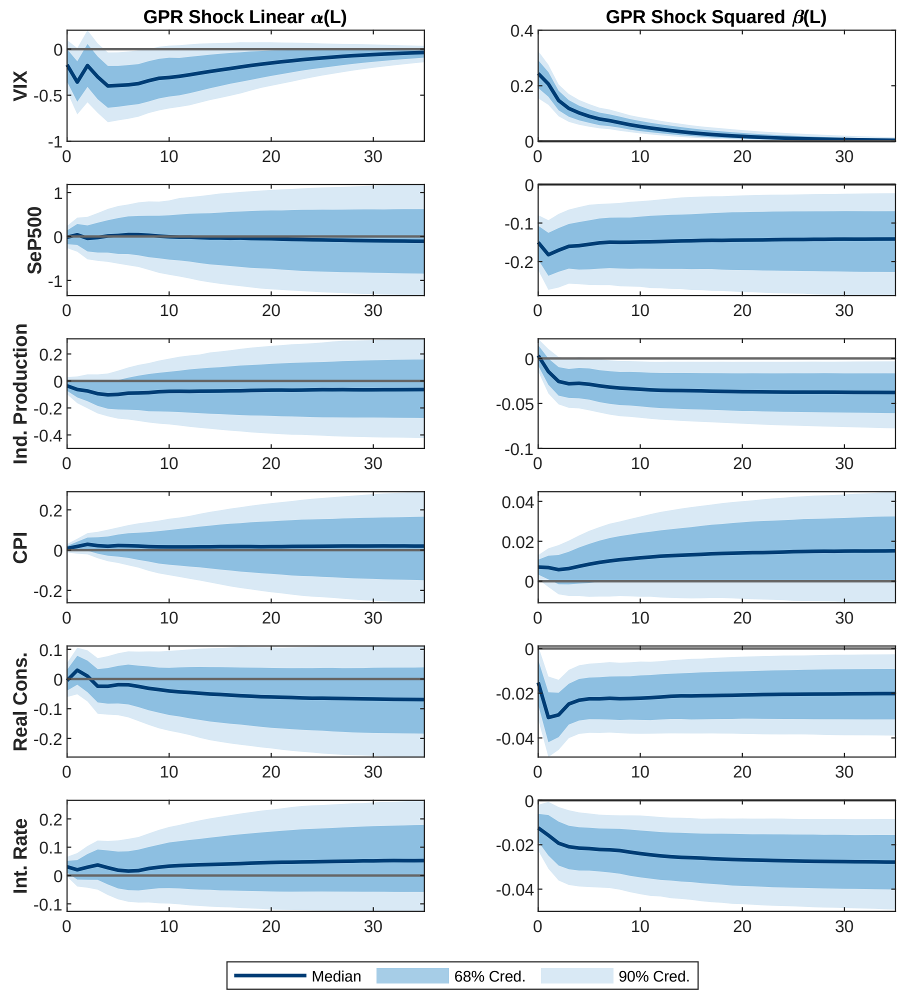
Figure 3 shows the IRFs obtained using the non-linear model estimated following the two-step procedure described in Section 3, with the left-hand side column showing $\alpha(L)$, while the right-hand side depicting $\beta(L)$. As evident from the first column to the left, the responses to the linear shock are different compared to those of the linear SVAR presented in Figure 2. Across almost all variables, responses to the linear shock exhibit subdued impacts and are generally less statistically significant. Some variables, such as the VIX and real consumption, even display a reversal in response direction at impact compared to those depicted in Figure 2. Overall, except for the IRFs of the VIX index after a few months and of industrial production and CPI at impact, the IRFs are not statistically significant at the 90% credible interval.

Conversely, the analysis of the IRFs to the non-linear shock - presented in the second column to the right - reveals a distinct scenario, with responses now predominantly significant across all variables. This indicates that $\beta(L) \neq 0$, and represents a first test showing the significance of the non-linear component associated with geopolitical risk shocks.

Notably, the quadratic GPR shock elicits a significant and positive response of the VIX, suggesting the importance of uncertainty in magnifying the impact of significant geopolitical shocks. Concurrently, industrial production and particularly real consumption exhibit notable negative and statistically significant responses. These responses can be attributed to increased overall uncertainty prompting precautionary savings and wait-and-see behaviors of households and firms, as suggested by the literature on uncertainty.[15] Equity prices also display significant negative reactions, potentially further impacting real consumption through the wealth effect. Finally,

[15]See for example Bernanke (1983), Kimball (1990), Bloom (2009) and Bayer et al. (2015).

Figure 3. Impulse Response Functions of the VARX: Linear vs Quadratic GPR shock



Notes: Plot of $\alpha(L)$ and $\beta(L)$ as defined in equation 4. The solid blue line represents the median response, while the shaded bands the 68% and 90% credible intervals. The left column shows the responses to the linear shock, while the right column the responses to the non-linear shock.

while the quadratic shock leads to an increase in the CPI, it also triggers a negative response in the policy rate. Although beyond the scope of this paper, the trade-off between prices and the policy rate's reaction may be explained by policymakers assigning greater weight to activity than inflation during such shocks. Further analysis of the impact on prices will be conducted in Section 4.

3.4 When the Size of Positive Shocks Matters

Having established the significance of the non-linear component, i.e., $\beta(L)$, for the variables incorporated in our model, we now investigate the overall impact of the geopolitical risk shock when accounting for both the linear and non-linear responses, as specified in equation (3). This entails aggregating the linear and quadratic components, i.e., the $\alpha(L)$ and $\beta(L)$ obtained in the second step, as elucidated in Section 2, introducing potential asymmetries in the magnitude of the shock. It is important to stress that we are not forcing any non-linearities here: if the estimated $\beta(L)$ is small or not significant, the overall responses would be just equal to the linear responses. Conversely, a $\beta(L)$ which is different than zero may lead to different overall responses compared to those analysed in 3.2, especially as the magnitude increases.

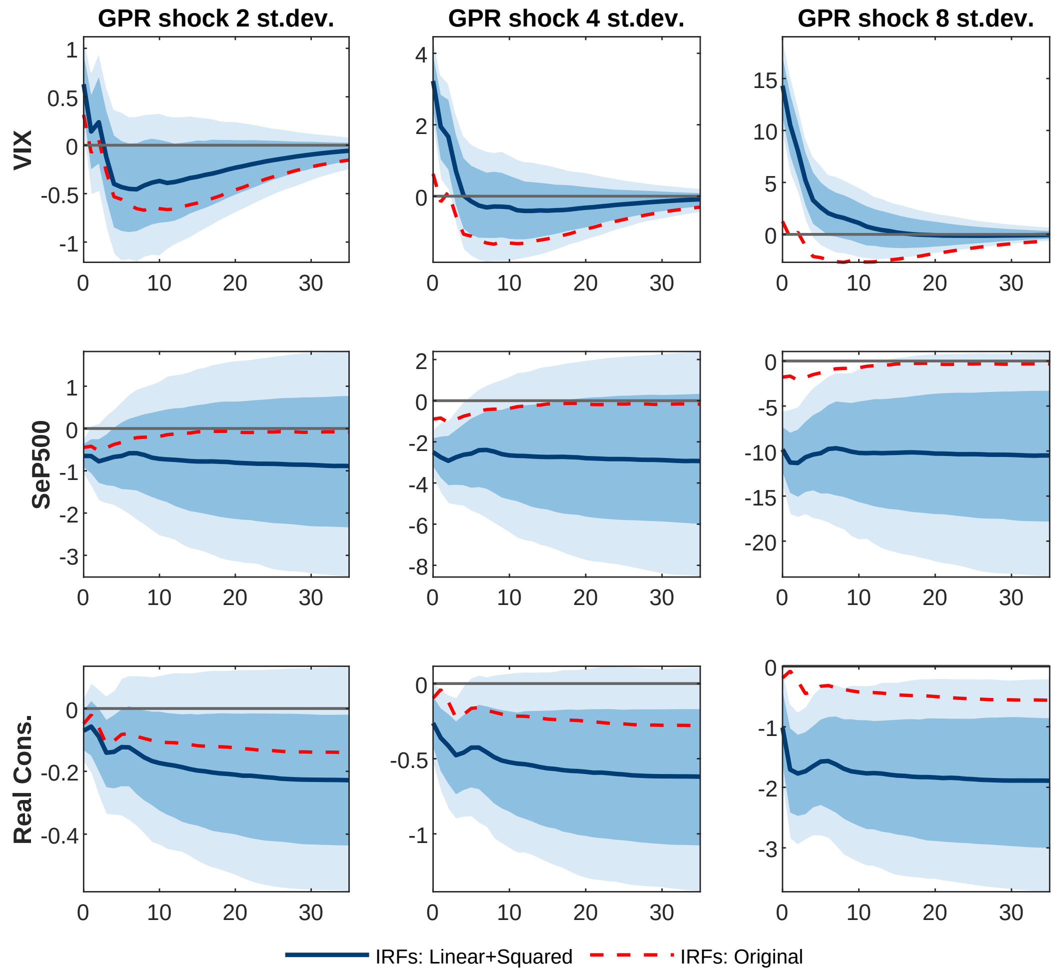
Figure 4 presents the IRFs to a geopolitical shock. Here we focus only on a subset of variables included in our model, namely the VIX, S&P 500, and real consumption, which are key indicators for our analysis. Nevertheless, Figure B2 in Appendix B shows the results for all variables included in the model. We examine the responses to various sizes of positive shocks, guided by the observations made when commenting Figure 1, and we analyse how variables respond to shocks equal to 2, 4, and 8 standard deviations, each depicted in a separate column.

The figure depicts the median IRFs resulting from the sum of the linear and quadratic components (blue solid line), accompanied by the 68% and 90% credible intervals (shaded areas), along with *original* IRFs obtained in the first step SVAR (red dashed line) as depicted in Figure 2. Importantly, both the *second-step* and *first-step* IRFs are rescaled according to the relative magnitude of the analysed shock, which allows for a proper identification of the differences between the two responses (i.e. the red and blue line are directly comparable as they reflect the same shock size).

We start our analysis with the two standard deviations shock (left-hand side column). Here, the responses obtained with the non-linear and linear models exhibit considerable similarity. There are already evident non-linearities in the VIX, in the S&P 500, and in real consumption, although only modest. The responses of the remaining variables, shown in Figure B2 in Appendix B, bring to similar conclusions as the one elucidated in Figure 2. This reaffirms that, with a relatively small shock, the transmission mechanism of a geopolitical risk shock remains largely unchanged compared to the analysis conducted in section 3.2. Thus, for such limited shocks, a linear model is a good approximation of the data generating process.

Nonetheless, with increasing magnitude, a distinct narrative unfolds. Focusing on the four standard deviations shock, depicted in the middle column, notable differences emerge in the responses of real consumption and the S&P 500. The second-step IRFs indicate significantly larger responses both at impact and throughout the entire

Figure 4. Impulse Response Functions of the VARX summing the linear and the non-linear responses to a GPR shock



Notes: The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock. IRFs are rescaled according to the relative magnitude of the analysed shock in both cases, facilitating straightforward comparison and enabling identification of differences between the two steps.

analysed horizon. Specifically, equity prices now exhibit a decline of 3% at impact, compared to a decrease of 0.8% in the first-step SVAR. For real consumption, the decline implied by the non-linear model is approximately 0.5% after a few months, while the red dashed line depicts a decrease less than half that magnitude. Most notably, the VIX displays the most substantial discrepancy between the two models: the non-linear VARX suggests a significant increase at impact of around 3 points, while in the linear SVAR it registers only a marginal (and statistically insignificant) rise of less than 1 point.

As anticipated in section 3.3, these findings suggest two observations. First, when geopolitical shocks are of small magnitude, non-linearities do not exert a significant influence on shock transmission. However, as the shock increases, non-linearities assume greater importance. Second, with increasing magnitude, non-linearities reveal a new channel through which the shock propagates: the VIX *increases*, and the uncertainty channel becomes highly relevant. This prompts precautionary behaviours among agents and amplifies the shock's effects through a decline in the S&P500 and real consumption, both directly impacted by the wealth effect stemming from the decrease in equity prices.

Overall, results emphasize the need to account for non-linearities to accurately assess the impact of GPR shocks onto the economy. At the same time, this also highlights that the principal transmission channel for this shock appears to be via heightened *standard* uncertainty channels. This becomes particularly apparent when analyzing the right-hand column, which depicts the responses to a shock of eight standard deviations. Here, the shock pushes the VIX up by 14 points in the two-step VARX, while decreasing equity prices by 10% and real consumption by nearly 2%. Conversely, without accounting for the non-linear component, the responses would be substantially smaller, and the shock would seem to have only a marginal impact on the economy. Furthermore, as illustrated in Figure B2, other variables now also exhibit notable differences: industrial production declines by around 3% compared to less than 1% implied by the first-step SVAR, while the policy rate decreases by around 1.5 percentage point in response to significantly weaker activity. Prices also increase, albeit the response is only marginally significant. We will delve further into the behavior of prices in Section 4.

3.5 Historical Decomposition of Selected Events

Based on the evidence presented in previous sections, we now investigate whether GPR shocks can account for (some of) the observed volatility of the variables analysed. To achieve this, we decompose the variables into three components: the portion explained by the linear shock, the portion explained by the non-linear shock, and a residual.[16] This approach allows us to assess both the *overall* significance of the GPR

[16]The residual can be interpreted as a reduced-form component comprising a combination of all the remaining structural shocks. Estimation of such structural shocks is beyond the scope of this analysis.

shock in explaining fluctuations in the variables, as well as the *relative* importance of the linear and non-linear components.

We examine the evolution of the variables during four specific historical events: the 9/11 terrorist attacks in 2001, the Gulf War starting in 1990, Russia's invasion of Ukraine which began in February 2022 and the Great Financial Crisis starting from September 2008 with the collapse of Lehman Brothers. The selection of these events is due to their heterogeneous nature and is informed by Figure 1; the first two events experienced a significant rise in geopolitical risk, leading to a substantial spike in the non-linear shock time series, while the third saw a more moderate increase in the shock. Finally, the fourth event should be unrelated to geopolitical dynamics and serves as a control-test for assessing the robustness of our approach.

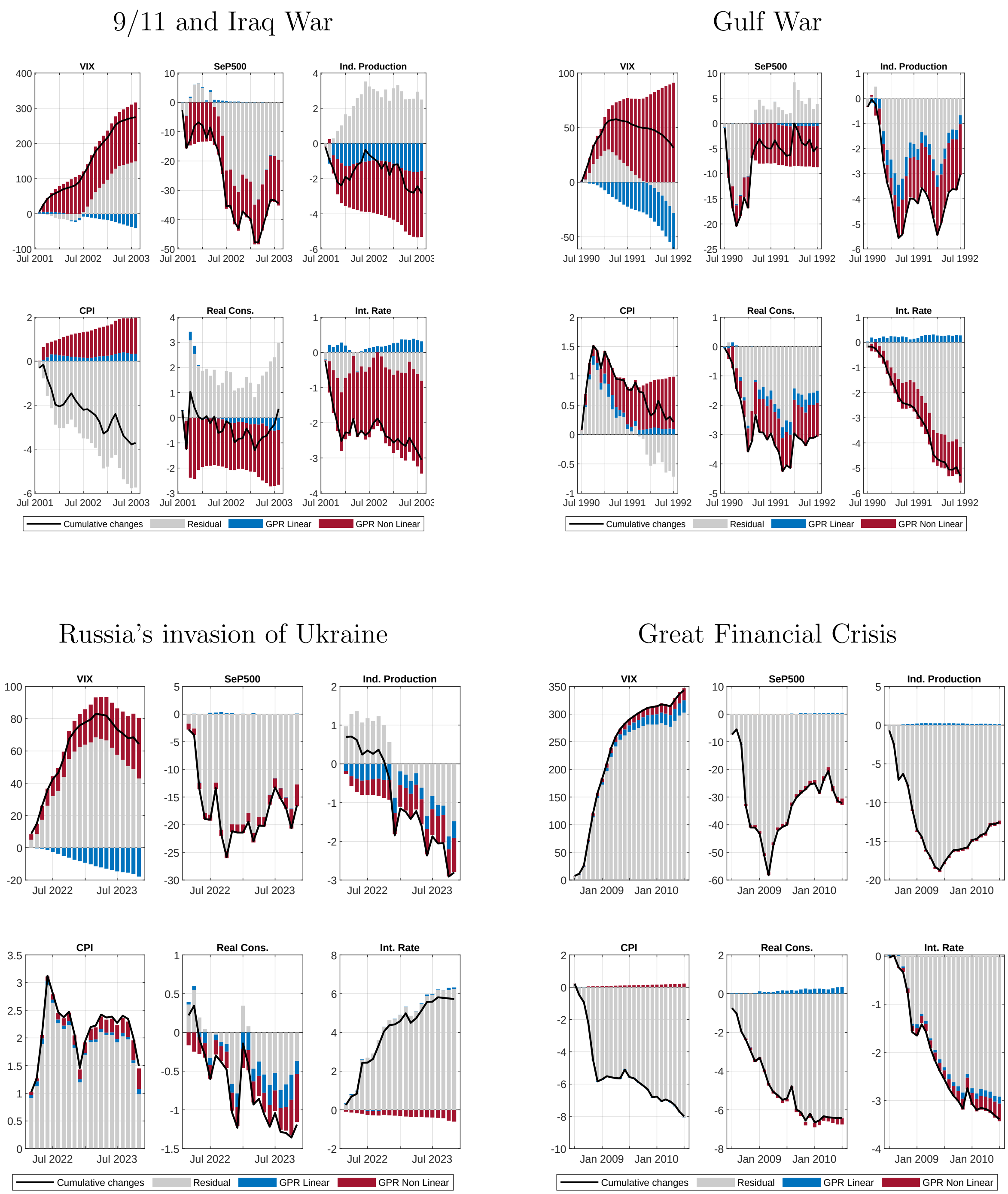
Figure 5 presents the results. The S&P500, real consumption, industrial production, and CPI are depicted as the cumulative sum of the log-changes over the two years from the onset of the selected event, while the VIX and the Fed funds rate are displayed as the cumulative sum (solid black line). The contribution of the linear shock is represented by the blue bars, while that of the non-linear shock is depicted by the red bars. Finally, the residual is shown in gray bars.

The geopolitical shock emerges as a significant driver in explaining the fluctuations observed in the variables during the period starting with the 9/11 attacks and continuing with the subsequent US invasion of Iraq, as illustrated in the top-left panel. The combined effect of the two components accounts for almost all of the variability observed in the VIX and the Fed funds rate, and a substantial portion of the S&P 500, industrial production, real consumption, and CPI. Further analysis of the individual components confirms our findings: non-linearities amplify the shock's effects through increased uncertainty, thereby influencing consumption, stock prices, and overall economic activity.

Conversely, by considering only the linear component, the role of the shock in explaining industrial production and CPI would be substantially lower, while the remaining variables would remain largely unexplained. A similar pattern is observed during the Gulf War episode, as depicted in the top-right panel, where the geopolitical shock, and particularly its non-linear component, explains a significant portion of the overall economic volatility.

The Russian invasion of Ukraine episode, shown in the bottom-left panel, shares similarities with the preceding two episodes. Here, the contribution of the geopolitical shock is more subdued due to the comparatively lower escalation of geopolitical risks

Figure 5. Historical Decomposition over Selected Episodes



Notes: Historical Decomposition over four different selected episodes. The black line depicts the cumulated sum of the log-changes, except for the Fed fund rate and the VIX index reported as the cumulated sum of the level. The blue bars show the contribution from the linear shock, the red bars the one from the non-linear shock. The gray bars are the residuals. The results reporter here correspond to the 50th percentile of the overall distributions.

in the US, with the residual shock explaining most of the fluctuations. This suggests that other factors, such as a broader supply shock, predominantly drove the notable price increases and the subsequent decline in economic activity and financial markets valuations.[17]

In conclusion, these results corroborate what we described in section 3.3 and 3.4: geopolitical risk shocks have an important role in explaining variables' fluctuations over some specific historical episodes. When large shocks occur, the non-linearities amplify the impact of the shock through an increase of the VIX, thus *switching on* the uncertainty channel. However, it is important to stress that geopolitical risk shocks are relatively unimportant for many other historical events. This is confirmed, for instance, by the bottom-right panel, which reports the decomposition around the great financial crisis. Here, as expected, geopolitical risk shocks do not play any role in explaining the overall volatility of the variables considered, despite the large increase in uncertainty illustrated by the spike in the VIX.

3.6 Robustness Checks

To validate our findings, we conduct several robustness checks. First, although we are interested in non-linearities that arise from a combination of size and sign, we use an alternative non-linear transformation of the shock, namely its cubic transformation which, as highlighted by Caravello and Martinez-Bruera (2024), is well suited to capture size non-linearities. As shown in Figure B3, results are robust also to this different specification. Second, we perform a battery of robustness checks over our baseline model specification. Specifically, (i) we estimate a model where we include Covid-19 dummies during the period of February 2020 to September 2020 using so-called pandemic priors as suggested by Cascaldi-Garcia (2022); (ii) we estimate the model considering the 1986-2019 sample which is the same one used by Caldara and Iacoviello (2022) and has the advantage of excluding the Covid-19 period; (iii) we estimate the model in log-levels.[18] Results are very robust to all the different specifications as shown in the Figures in Appendix B.

We also estimate the model by adding the dummy-initial-condition prior to control

[17] It is also important to stress that this analysis is based on US data, and the US economy was more insulated than other advanced economies to this specific event due to the lower reliance on energy imports from Russia. At the same time, price pressures in the US economy were also the result of the country emerging from the Covid-19 pandemic (see for example Blanchard and Bernanke (2023)).

[18] When estimated in log-levels, we set the prior on the coefficients equal to 1.

for possible uncertainty around the estimation of the deterministic component, which, as shown by Bergholt et al. (2023), may strongly influence the resulting historical decomposition. The historical decompositions obtained with this specification are plotted in Figure B7. Again, the results are very similar to those presented in Section 3.5.

Finally, we check if our results on uncertainty are robust across alternative measures of uncertainty. We therefore re-run the same exercise by using different uncertainty proxies and compare their IRFs to those of the VIX index. More precisely, we consider (i) US Consumer's perceived expectations based on the Michigan consumer sentiment survey, which is a widely used metric used in the literature to gauge uncertainty;[19] (ii) the Global Economic Policy Uncertainty Index (GEPUI) constructed by Baker et al. (2016) and (iii) the US Composite Indicator of Systemic Stress (CISS) constructed by Kremer and Chavleishvili (2021).

Consumer perception of uncertainty stems from responses collected in the Michigan consumer sentiment survey. This metric is formulated as the proportion of respondents indicating unfavorable timing for vehicle purchases due to uncertain future economic conditions. The GEPUI is derived from newspaper coverage to capture policy-related economic uncertainty. Finally, the CISS index is constructed using fifteen indicators to gauge financial stress across various markets, encompassing money markets, bond markets, equity markets, and foreign exchange markets.[20]

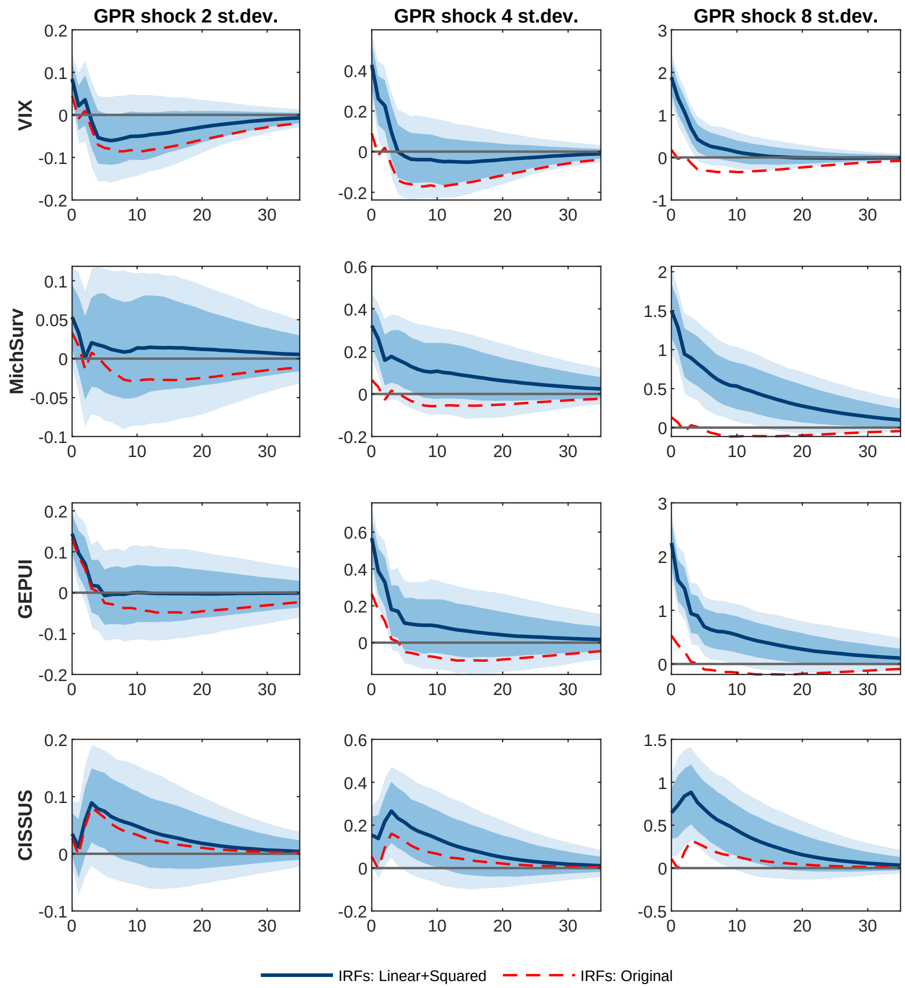
The correlation between these indicators and the VIX varies, ranging from 0.3 for the index derived from the consumer sentiment survey to 0.44 for the GEPUI, and reaching 0.8 for the US CISS index.

Figure 6 shows the standardized response of each of different uncertainty proxy to a GPR shock, with the VIX displayed in the first row. The solid blue line shows the median response of the non-linear model, while the dotted red line shows the response of the uncertainty variables to a GPR shock identified with the linear model. Columns one through three depict the response for shocks of two, four, and eight standard deviations, respectively. All the considered uncertainty measures exhibit responses broadly aligned with the VIX. Notably, they all demonstrate non-linearities emerging as the size of the shock increases, exhibiting a roughly comparable increase

[19]See for example De Santis and Van der Veken (2022).

[20]Systemic stress is computed by assigning weights to each pair of indicators based on their time-varying correlation coefficient. This approach allows the CISS to assign greater significance to scenarios where stress pervades multiple market segments simultaneously, thereby capturing second-moment dynamics beyond stock market volatility and exhibiting greater persistence.

Figure 6. Robustness on Uncertainty Measures



Notes: The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock. Each row shows the responses of different measures of uncertainties. All the uncertainty measures are standardized.

in magnitude, ranging between 0.2 and 0.4 standard deviations for a 4 standard deviation shock, and between 1 and 2 standard deviations for an 8 standard deviation shock. Overall, this analysis further confirms our baseline results and in particular that large geopolitical risk shocks transmit through the uncertainty channel.

4 Unpacking Inflation Dynamics: The Role of GPR Threats and Acts

Our analysis has revealed only a mild positive price reaction to GPR shocks, with also rather limited asymmetries observed in response to variations in the shock magnitude. Nevertheless, understanding how prices react to GPR shocks has become increasingly important. We delve deeper into this issue by making use of two different geopolitical risk indices proposed by Caldara and Iacoviello (2022), namely the Geopolitical Threats (GPRT) and the Geopolitical Acts (GPRA) index.

This approach allows us (i) to discern if GPRA and GPRT shocks have similar or contrasting effects on prices, (ii) if one of the two indexes has a stronger role in driving them, and eventually (iii) we can gain insights into why the price response following the aggregated index is relatively subdued.[21] This distinction is relevant as the authors showed that Acts shocks relate to the realisation of risk which can imply potential destruction of physical capital and are more akin to disaster events. Threats are instead by definition about expected future disruptions and are more closely related to the uncertainty channel, although the literature on the topic has stressed that uncertainty is endogenous and might increase in both cases (Ludvigson et al. (2021)).

We follow the same strategy described in the previous sections, but with a fundamental modification as we incorporate both the GPRA and GPRT indices instead of the broader GPR index. GPRA and GPRT shocks are then identified using a recursive algorithm, with the Acts index ordered before the Threats index to isolate acts that do not generate increased uncertainty, consistent with the approach adopted by Caldara and Iacoviello (2022). In the robustness section in Appendix C, we also explore an alternative ordering with the GPRT preceding the GPRA index.

Additionally, as our focus is on prices, we add three more variables to the SVAR: real oil prices, one-year-ahead inflation expectations, as measured by the Michigan survey of consumer expectations, and core personal consumption expenditure (core PCE). We include Oil prices as they are largely affected by geopolitical risk episodes and given the importance that energy prices can have on overall price dynamics. We consider a measure of inflation expectations to study potential changes in consumers' views about the future development of inflation, capturing an additional channel

[21] While Caldara and Iacoviello (2022) highlight heterogeneity in the transmission of shocks deriving from GPRA and GPRT, they do not explore how prices react to the two different components.

related to the feedback loop that goes from expectations of price increases to actual increases in inflation. Finally, core PCE is included to check if potential movements in broader price measures are directly linked to the mechanical impact of energy prices or if they are also related to price increases in other sectors, as energy is an important input in many other sectors of the economy.

Subsequently, we implement a two-step strategy akin to the one implemented in Section 3: we estimate a SVAR model without accounting for possible non-linearities, we retrieve the two shock series, and then estimate a VARX with the linear GPRA and GPRT shocks and their respective non-linear transformations. Model specification and estimation follow the description of Section 3, the only difference being that for this analysis data starts in 1978 as this is the first available observation for the one-year ahead inflation expectation.

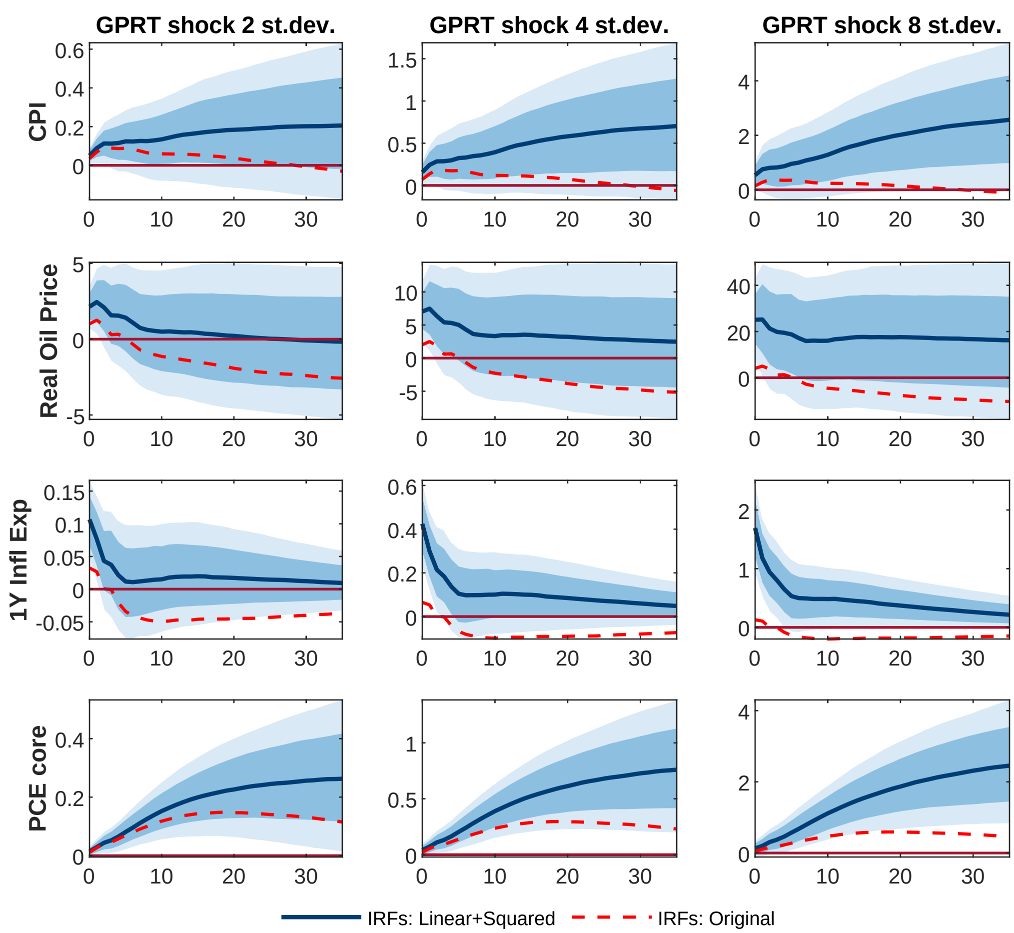
Our description of the results focuses on the responses of price measures, while the remaining IRFs can be found in Appendix C. We start with the responses to a GPRT shock. Figure 7 illustrates in three distinct columns the IRFs following respectively a 2, 4 and 8 standard deviations shock. Again, the blue line shows the response to the linear and the non-linear transformation combined, together with the 68% and 90% credible intervals in light blue, while the dashed red line represents the estimated responses from a simple linear SVAR model.

As evident from Figure 7, GPR Threats shocks have a non-trivial effect on the inflation's components. The IRFs analysis uncovers two possible complementary channels that can explain this result: an increase in oil prices compounded by a significant spike in inflation expectations, which could reinforce the overall effect and make it more persistent. The two can also explain the reaction of the PCE core, which is a more domestic-based inflation index. PCE is initially slower to react but, towards the third year, depicts a similar positive impact in both size and magnitude to that of CPI. This may suggest that the effect of the shock is not limited only to an increase in external price factors, and that higher oil prices may eventually spill over to domestic goods and services prices.

Results are also complemented by the analysis of non-linearities, that arise already with just a two standard deviation shock and become particularly evident at four and eight standard deviations. Importantly, non-linearities affect all the inflation indices we include in the model. Non-linearities in oil prices are particularly evident as the size of the shock increases and are compounded with those observed in the one-year ahead inflation expectations, along with the CPI and PCE core.

Overall, the impact on oil prices is consistent with an increase in speculative demand for oil as markets anticipate potential future disruptions in oil supply, aligning with findings in the literature on oil prices (Kilian and Murphy, 2014; Juvenal and Petrella, 2015; Cross et al., 2022). The positive response of prices is also consistent with non-linear DSGE models with nominal frictions such as Fernández-Villaverde et al. (2015), Born and Pfeifer (2017), and Andreasen et al. (2024) which show the firms' upward pricing (precautionary pricing) bias in response to uncertainty shocks to ensure themselves against future states characterized by high future marginal costs.

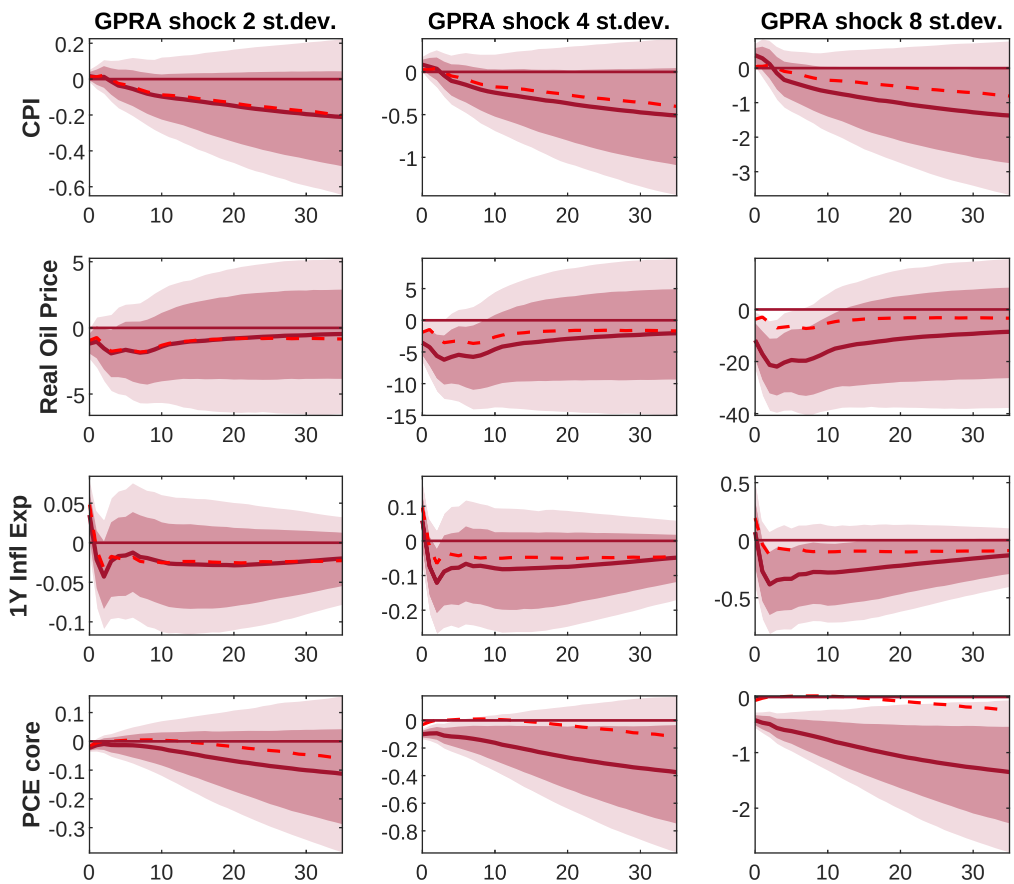
Figure 7. Price responses to GPR Threats



Notes: The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock. IRFs are rescaled according to the relative magnitude of the analysed shock in both cases.

Figure 8 depicts the IRFs to a GPR Act shock. Responses related to the non-linear model are shown by the continuous red line, while the dashed line - as in the previous case - describes the response of the linear model.

Figure 8. Price responses to GPR Acts



Notes: The solid red line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock. IRFs are rescaled according to the relative magnitude of the analysed shock in both cases.

There are important differences compared to what analysed for the GPR Threats shocks, both in the transmission to prices and in the analysis of non-linearities. The Acts shock induces a decline in oil prices and the response of expected inflation is not statistically significant at impact. CPI and PCE core responses are also not significant at impact and become negative thereafter. Second, non-linearities are much less pronounced: they are absent if we consider the two and four-standard deviation shocks, while they modestly emerge in the case of very large and positive

GPRA shocks (around 8 standard deviations).

The comparison between the two subcomponents of the GPR index thus suggests that GPR Acts shocks transmit more similarly to a negative demand shock - or first-moment - shock, while GPR *Threats* shocks are closer to second-moment positive uncertainty shock. This is in line with the interpretation that non-linearities are mostly a consequence of higher uncertainty, which is not directly captured by the GPR Act index, while in the case of GPR Threats shock, uncertainty was fueling a higher precautionary demand for oil, that consequently was transmitted into domestic inflation also via an increase of inflation expectations.[22]

Overall, we find that the two shocks have opposite effects on prices, potentially explaining the relatively muted response of CPI to a generic geopolitical risk shock. This highlights that GPR shocks capture a multifaceted phenomenon and that policymakers need to know the exact reason behind the increase of geopolitical risk to design an adequate policy response.

5 Conclusion

Our analysis sheds light on the intricate dynamics surrounding geopolitical risk shocks.

We highlight the importance of considering both linear and non-linear components and show how larger magnitude shocks produce marked non-linear dynamics, which greatly amplify the overall impact of GPR shocks on the economy.

Including non-linearities helps unveil one important channel through which geopolitical risk shocks propagate: when the size increases and non-linearities kick in, uncertainty spikes, prompting significant negative responses of equity prices and real consumption, a result that is consistent with the literature that describes precautionary and wait-and-see behaviours from households and firms under periods of elevated uncertainty.

We delve into the effect of GPR shocks on prices. We find that prices respond positively to the shock, but the overall impact is subdued compared to other variables. We show that this is due to the counteracting effects of the two subcomponents of GPR shocks, namely GPR Acts and GPR Threats, which exert an opposite effect on inflation.

We document that GPR Acts shocks are closer to first-moment negative demand

[22]It is worth noting that the VIX index (as shown in the appendix) increases non-linearly also in the case of an Act shock, probably as a result of an increase in geopolitical threats following the materialisation of risk, a result that was also shown by Caldara and Iacoviello (2022).

shocks as decrease prices and are subject to only limited non-linearities when the size of the shock increases. Conversely, GPR Threat shocks, akin to second-moment uncertainty shocks, cause prices to grow. This is consistent with two complementary explanations: (i) a raise in the speculative demand for oil as markets anticipate potential future disruptions pushing oil prices and CPI up, which may then feed into an increase of inflation expectation and spill over into an increase of measures of domestic inflation; (ii) a precautionary pricing/upward pricing bias behaviour, where firms set prices higher to ensure themselves against future states characterized by high future marginal costs. GPR Threats shocks, contrary to the GPR Acts shocks, also depict significant non-linearities when the magnitude increases.

These findings hold significant implications for policymakers and market participants. For instance, the increase in shocks' magnitude intensifies the policymaker's trade-off between stabilising output and lowering price pressures. Moreover, some shocks predominantly affect the demand side of the economy, decreasing price pressures, others propagate through rising oil prices and heightened inflation expectations, increasing the risk of second-round effects. This emphasizes the importance of a better understanding of the source of geopolitical shocks to better calibrate their policy response to safeguard economic and financial stability.

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A Appendix

Appendix Table A1. Geopolitical Events Corresponding to Shock Episodes

Episode	Description
Vietnam War: Easter Offensive	Attack of the North Vietnamese Army (April 7, 1972,) on the South Vietnamese city of An Loc as part of their ongoing "Easter Offensive".
Yom Kippur	The Yom Kippur War (October 6–25, 1973), a conflict between Israel and a coalition of Arab states led by Egypt and Syria.
Israel-Lebanon	The 1978 South Lebanon conflict (Operation Litani), an Israeli invasion of southern Lebanon following attacks by the PLO.
Afghanistan	The Soviet invasion of Afghanistan (December 1979), marking the beginning of a decade-long conflict during the Cold War.
Falkland	The Falklands War (April–June 1982), a conflict between Argentina and the United Kingdom over the Falkland Islands.
Soviet nuclear alarm	The Soviet nuclear false alarm incident (September 26, 1983), where a malfunction almost triggered a nuclear war.
TWA flight	The hijacking of TWA Flight 847 (June 14–30, 1985) by Hezbollah-affiliated terrorists.
US-Libya	The 1986 United States bombing of Libya (April 15), in response to Libyan state-sponsored terrorism.
Iraq-Kuwait	The Iraqi invasion of Kuwait (August 2, 1990).
Gulf war	The Gulf War (January–February 1991), a US-led coalition operation to liberate Kuwait from Iraqi forces.
Air strikes to Iraq	Numerous coalition airstrikes occurred against Iraq in response to actions by the latter predominantly due to the No-Fly Zone in Southern Iraq
NATO-Serbia	The NATO bombing of Yugoslavia (March–June 1999) during the Kosovo War, aiming to halt human rights abuses.
Oper. Desert Fox	Operation Desert Fox (December 16–19, 1998), US and UK airstrikes targeting Iraqi weapons facilities.
Kosovo war	The Kosovo War (1998–1999), a conflict in the Balkans ending with NATO intervention to halt ethnic cleansing.
11/09	The September 11, 2001 terrorist attacks on the United States by al-Qaeda, leading to the War on Terror.
Iraq war	The Iraq War (March 2003–2011), initiated by a US-led coalition to overthrow Saddam Hussein.
London bombing	The July 7, 2005 London bombings, a series of coordinated Islamist terrorist attacks on public transport.
Bin Laden death	The killing of Osama bin Laden (May 2, 2011) by US forces in Pakistan, marking a milestone in the War on Terror.
Crimea	The annexation of Crimea by Russia (March 2014) following the Ukrainian revolution and unrest in Eastern Ukraine.
Paris	The November 2015 Paris attacks by ISIS, targeting civilians in multiple locations, including the Bataclan theater.
US-Iran tensions	Increased US–Iran tensions (January 2020), including the killing of Iranian General Qasem Soleimani.
Russia-Ukraine	The Russian invasion of Ukraine (February 24, 2022), escalating into a full-scale war with global consequences.
Gaza	Escalation of the Israeli–Palestinian conflict in Gaza (October 2023), marked by intense airstrikes and ground operations.

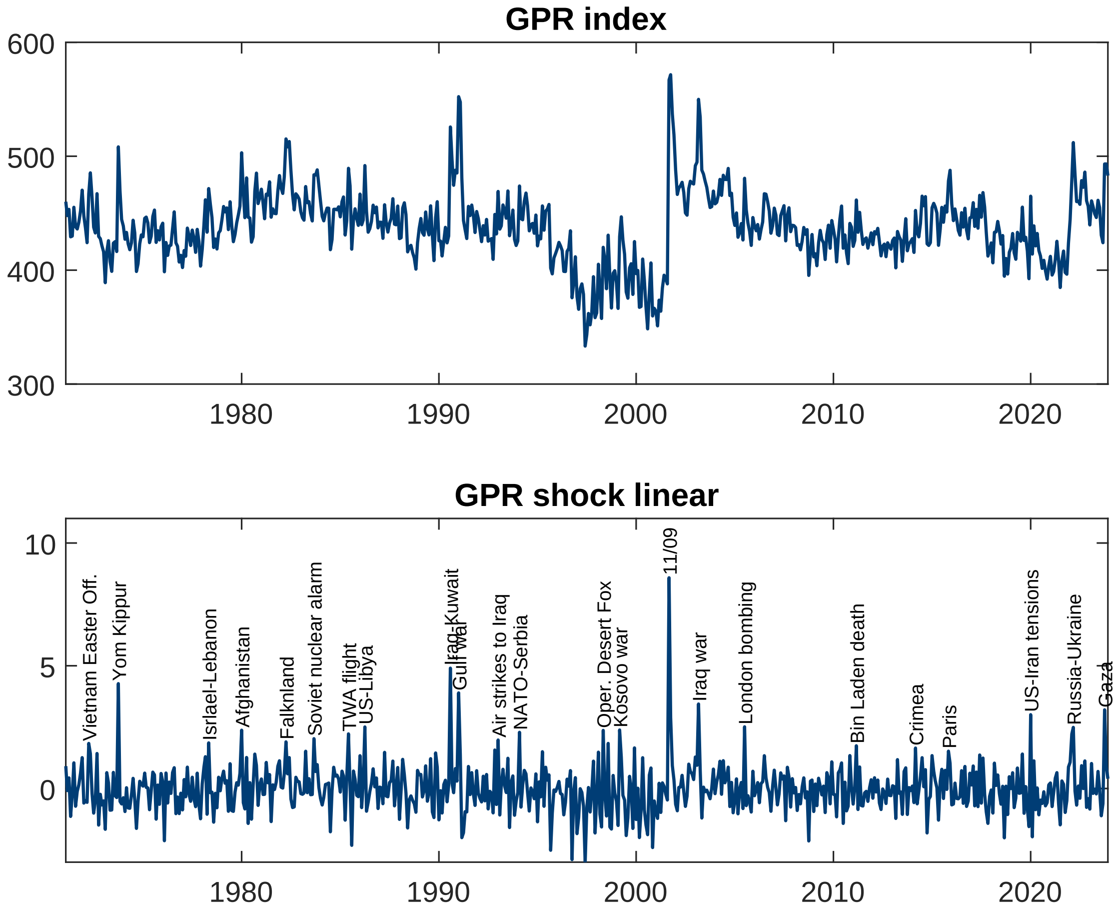
Appendix Table A2. Variables used in the analysis, descriptions, source and transformation

Variable	Description	Source	Transformation
GPR; GPRT; GPRA	Geopolitical Risk Index	Caldara and Iacoviello (2022)	diff(log(x))*100
VIX	CBOE Volatility Index	Chicago Board Options Exchange	Levels
S&P500	S&P 500 Index, deflated by Consumer Price Index for All Urban Consumers	Standard & Poor's	diff(log(x))*100
Ind. Production	Industrial Production Index	Federal Reserve Board	diff(log(x))*100
CPI	Consumer Price Index for All Urban Consumers	Bureau of Labor Statistics	diff(log(x))*100
Real Cons.	Real Consumption Expenditure	Bureau of Economic Analysis	diff(log(x))*100
Int. Rate	Fed Funds Rate	Federal Reserve Board	Levels
Real oil price	West Texas Intermediate price of oil, divided by the Consumer Price Index for All Urban Consumers	Energy Information Admin and Chicago Mercantile Exchange	diff(log(x))*100
1Y E(π)	Expected Inflation Rate, Next Year	University of Michigan	diff.
PCE core	Personal Consumption Expenditure less Food and Energy	Bureau of Labor Statistics	diff(log(x))*100

Note: All variables sourced via Haver Analytics. The Federal Funds Rate has been augmented with the US Shadow Rate from Wu and Xia (2016).

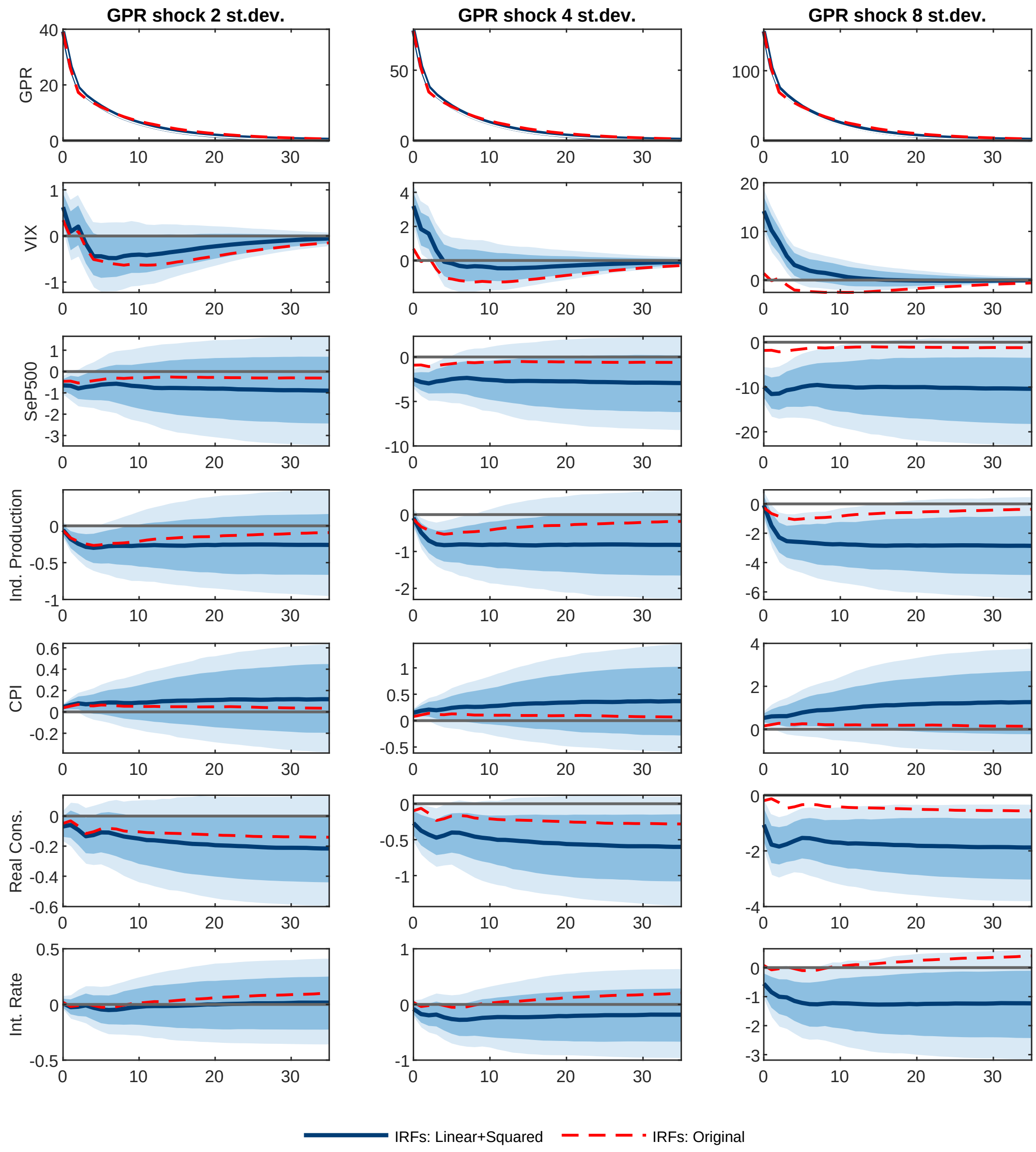
B Appendix: Robustness and Additional Figures

Appendix Figure B1. GPR index vs linear shock



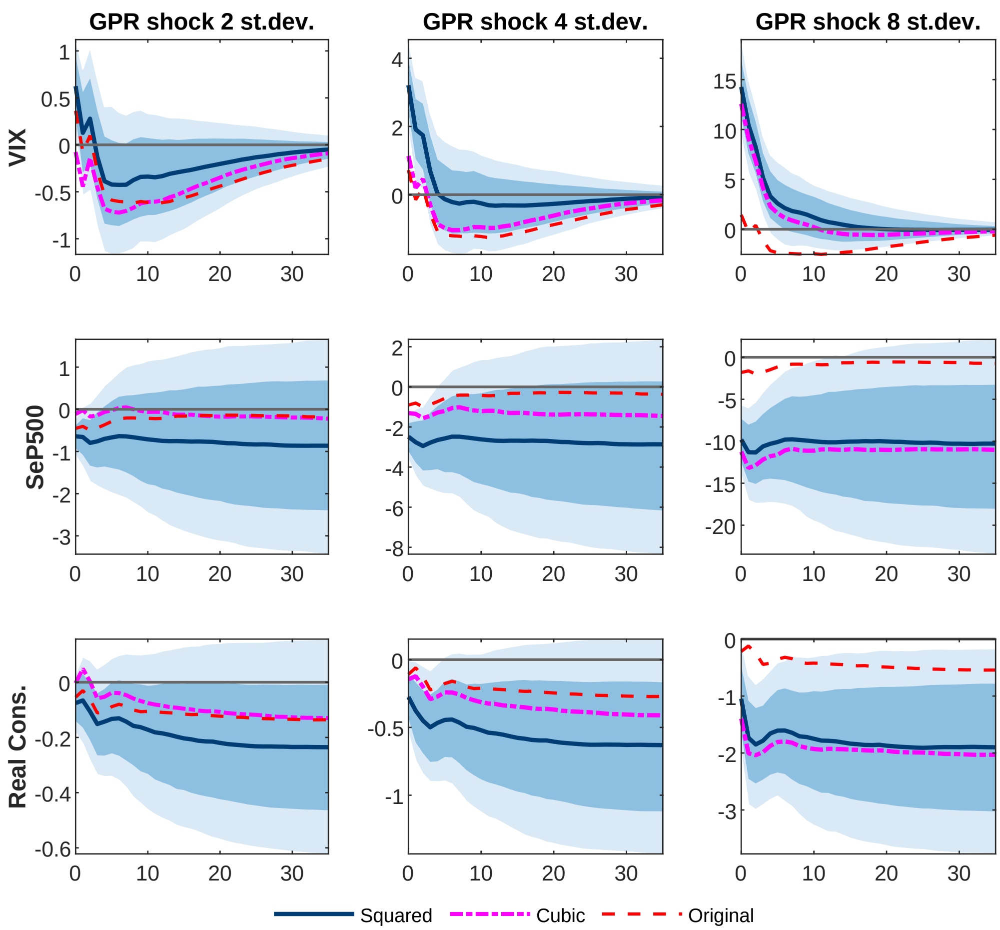
Notes: Geopolitical shock index (top panel) along with the shock estimated in the linear SVAR model (bottom panel). Positive values correspond to an increase in Geopolitical Risk. Labels refer to particularly large geopolitical events and are described more extensively in table A1 in Appendix A.

Appendix Figure B2. Impulse Response Functions of the VARX using the linear and the non-linear GPR shock.



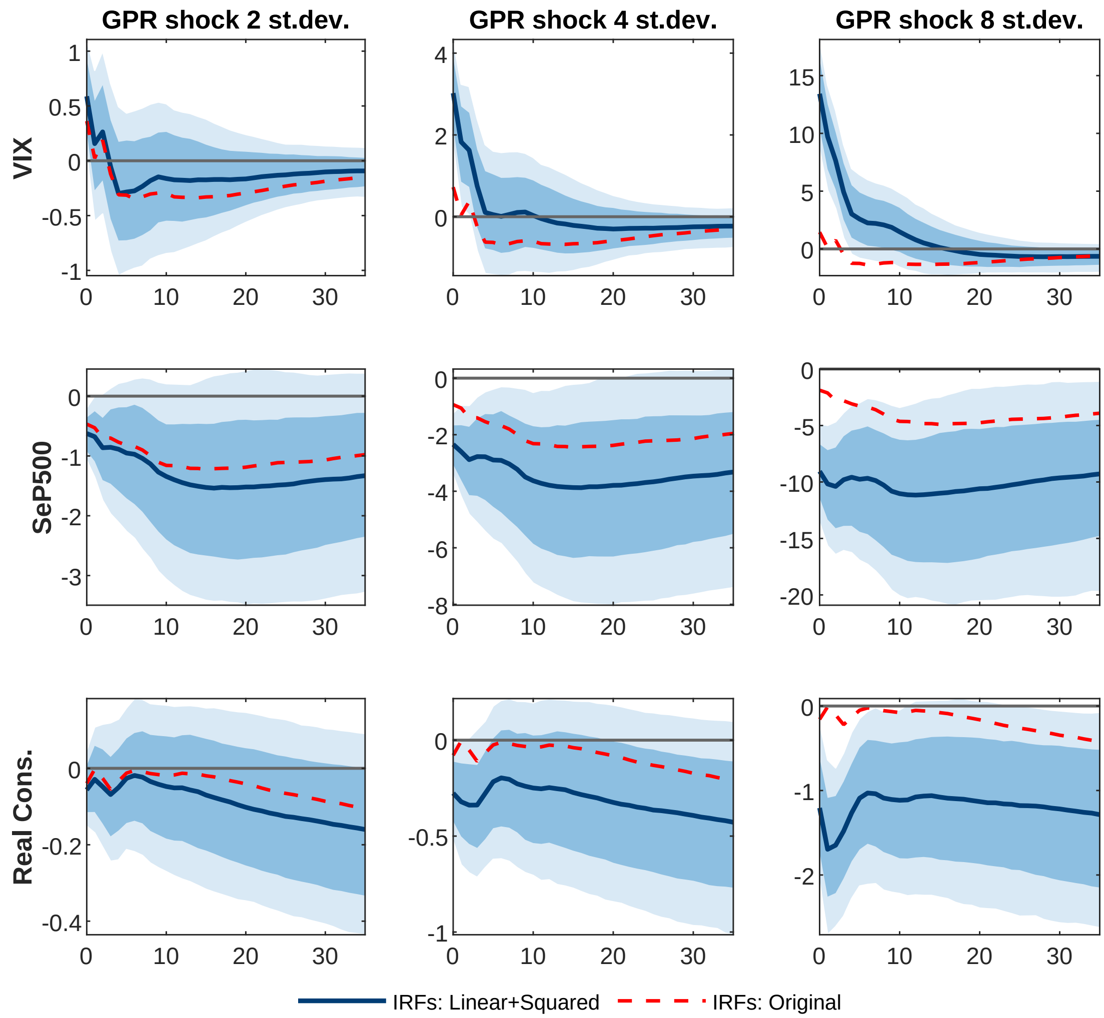
Notes: Baseline specification - all variables included in the model. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure B3. Alternative non-linear specification of the shock



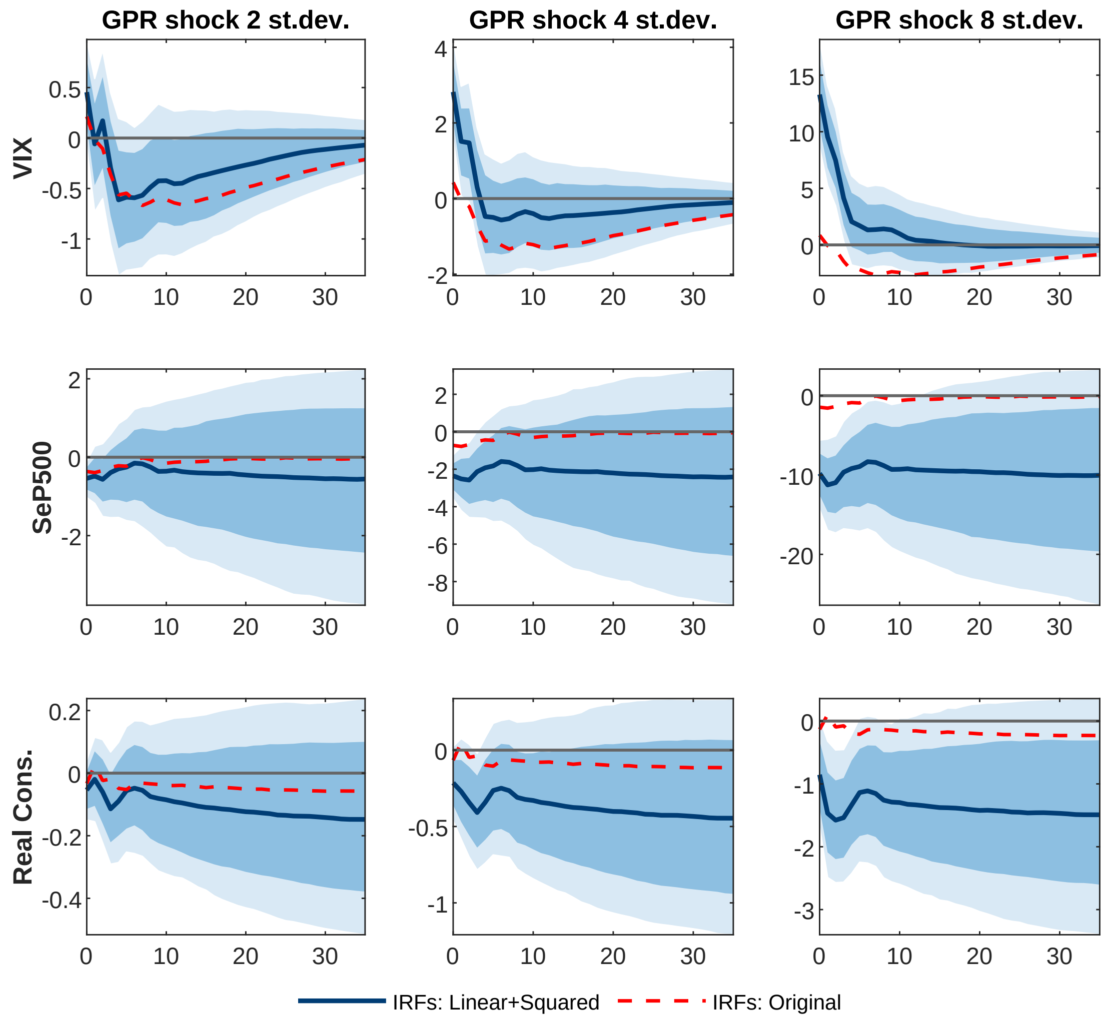
Notes: Results using using a cubic instead than a squared transformation of the non-linear component of the shock. The solid blue line represents the median response of the overall linear and non-linear (squared transformation) responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The purple dashed line represents the median response of the overall linear and non-linear (cubic transformation) responses estimated in the second step. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure B4. Robustness: Level Specification



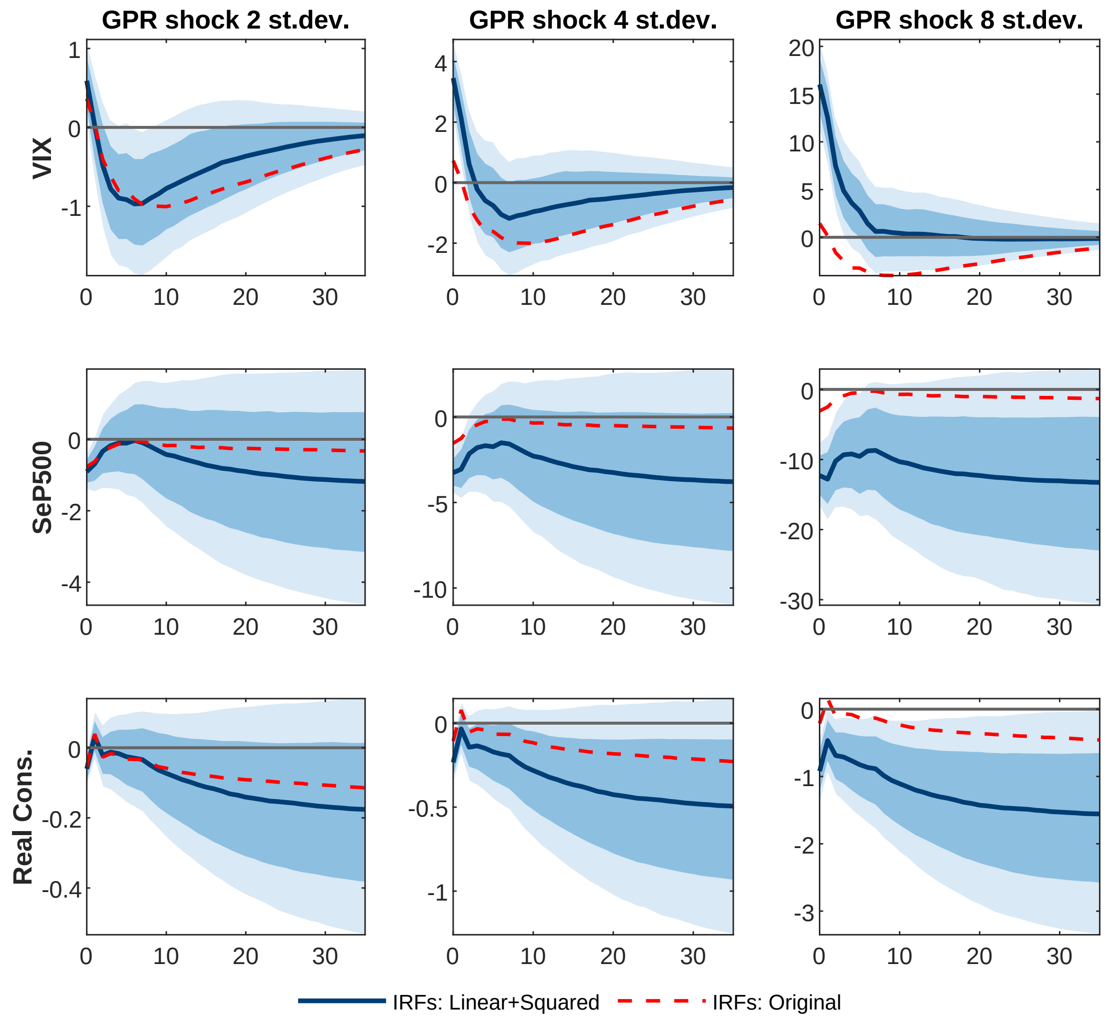
Notes: Specification considering the variables in levels. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure B5. Robustness: Covid-19 Dummies



Notes: Specification considering Covid-19 dummies as in Cascaldi-Garcia (2022). The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

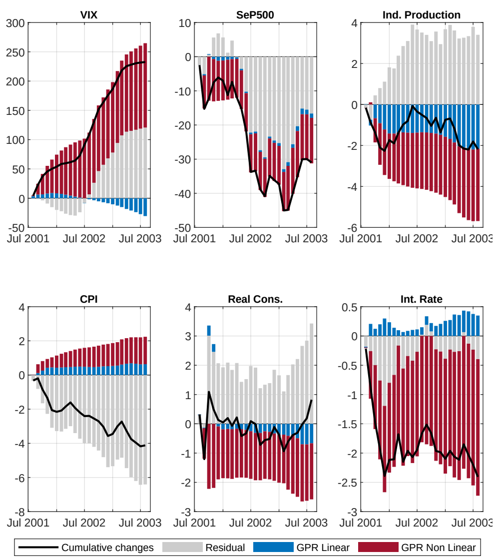
Appendix Figure B6. Robustness: Sample 1986-2019



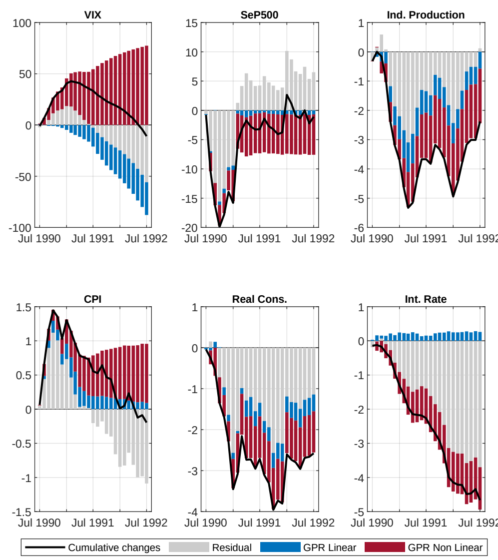
Notes: Selected results using the sample 1986M1-2019M12 as in Caldara and Iacoviello (2022). The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure B7. Robustness: Single-unit prior and Historical Decomposition

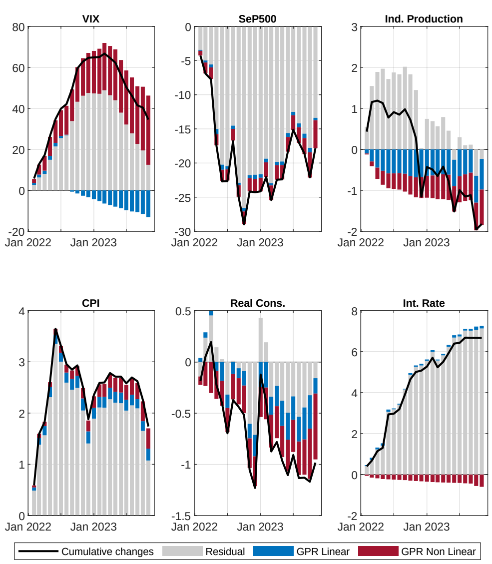
9/11 and Iraq War



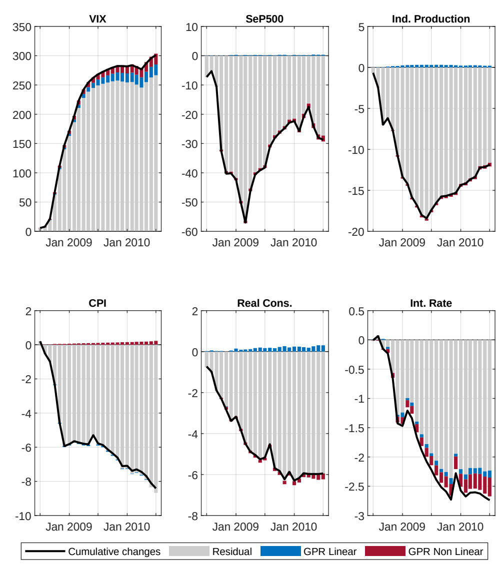
Gulf War



Russia's invasion of Ukraine



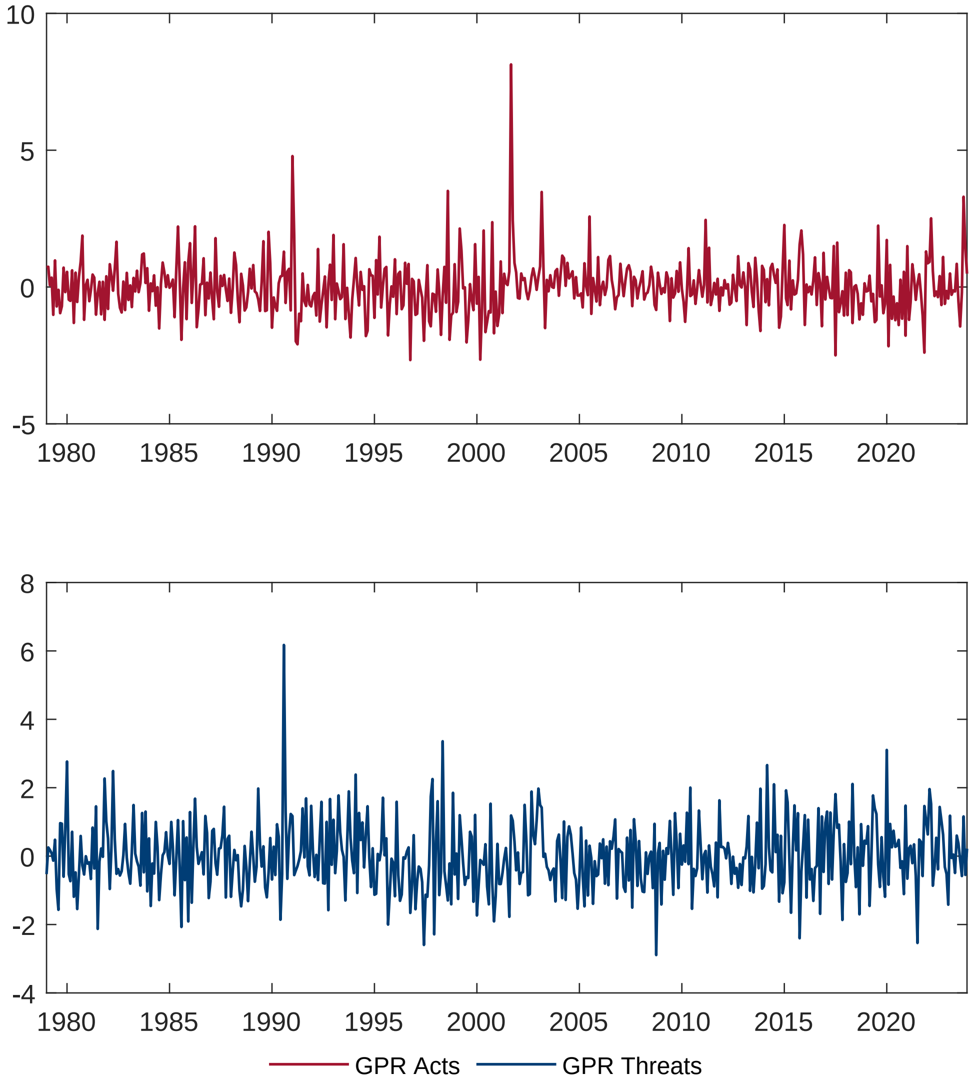
Great Financial Crisis



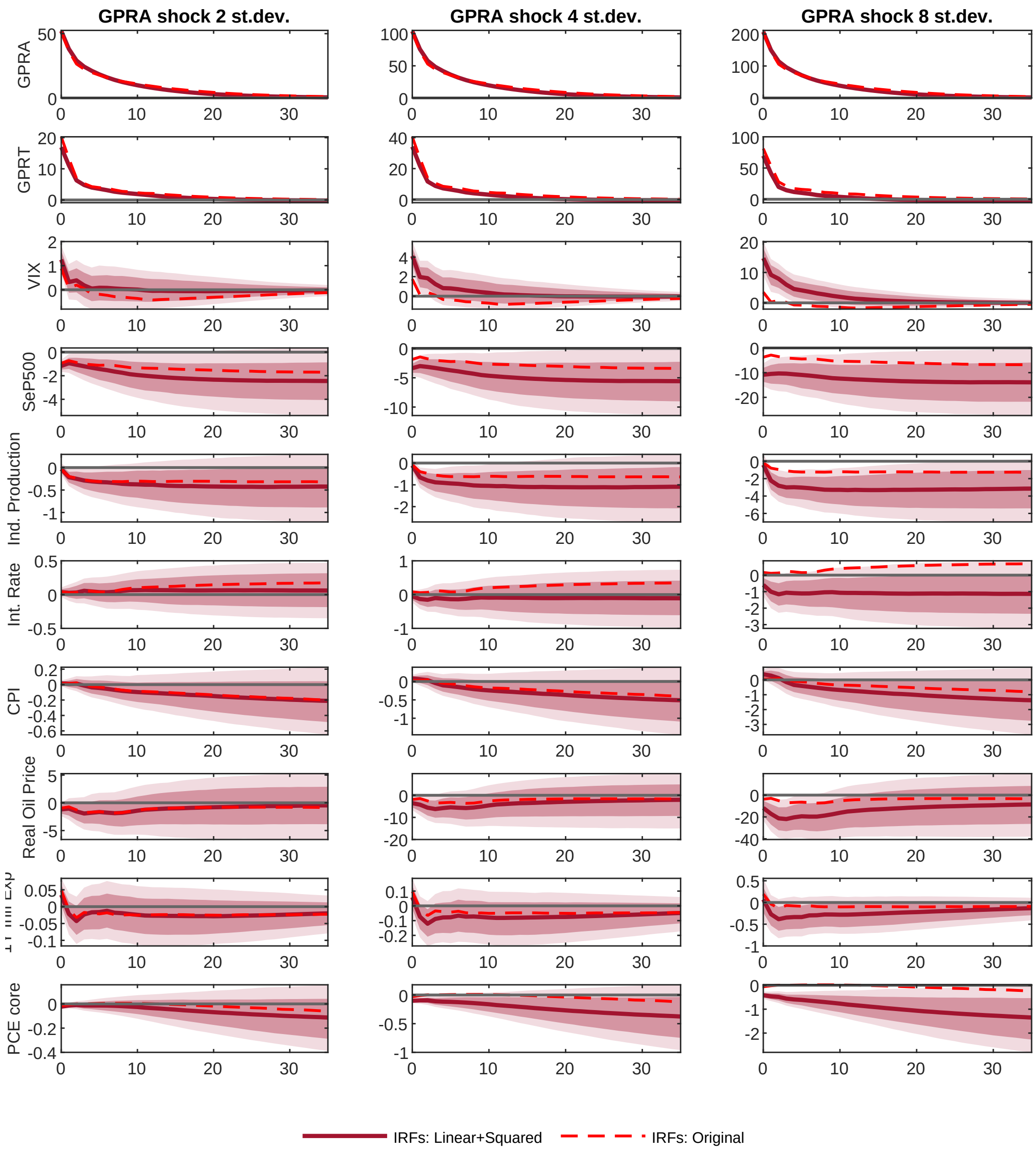
Notes: Historical Decomposition over four different selected episodes, model specification with dummy-initial-condition prior to account for the uncertainty around the deterministic component. The black line depicts the cumulated sum of the log-changes, except for the Fed fund rate and the VIX index reported as the cumulated sum of the level. The blue bars show the contribution from the linear shock, the red bars the one from the non-linear shock. The gray bars are the residuals. The results reporter here correspond to the 50th percentile of the overall distributions.

C Appendix: GPRA vs GPRT

Appendix Figure C1. GPRA vs GPRT shocks

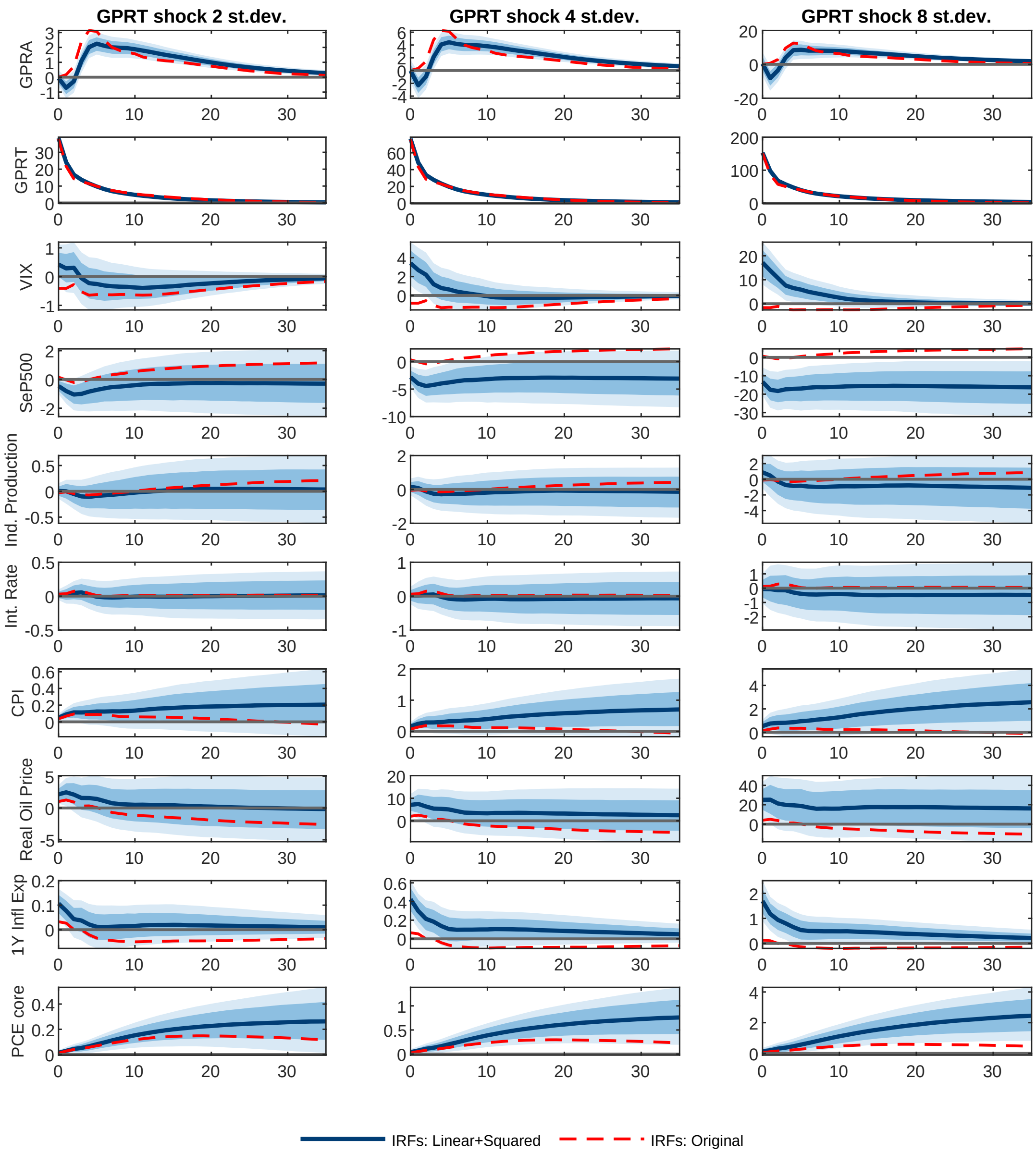


Appendix Figure C2. GPRA: IRFs of the VARX summing the linear and the non-linear responses to a GPRA shock



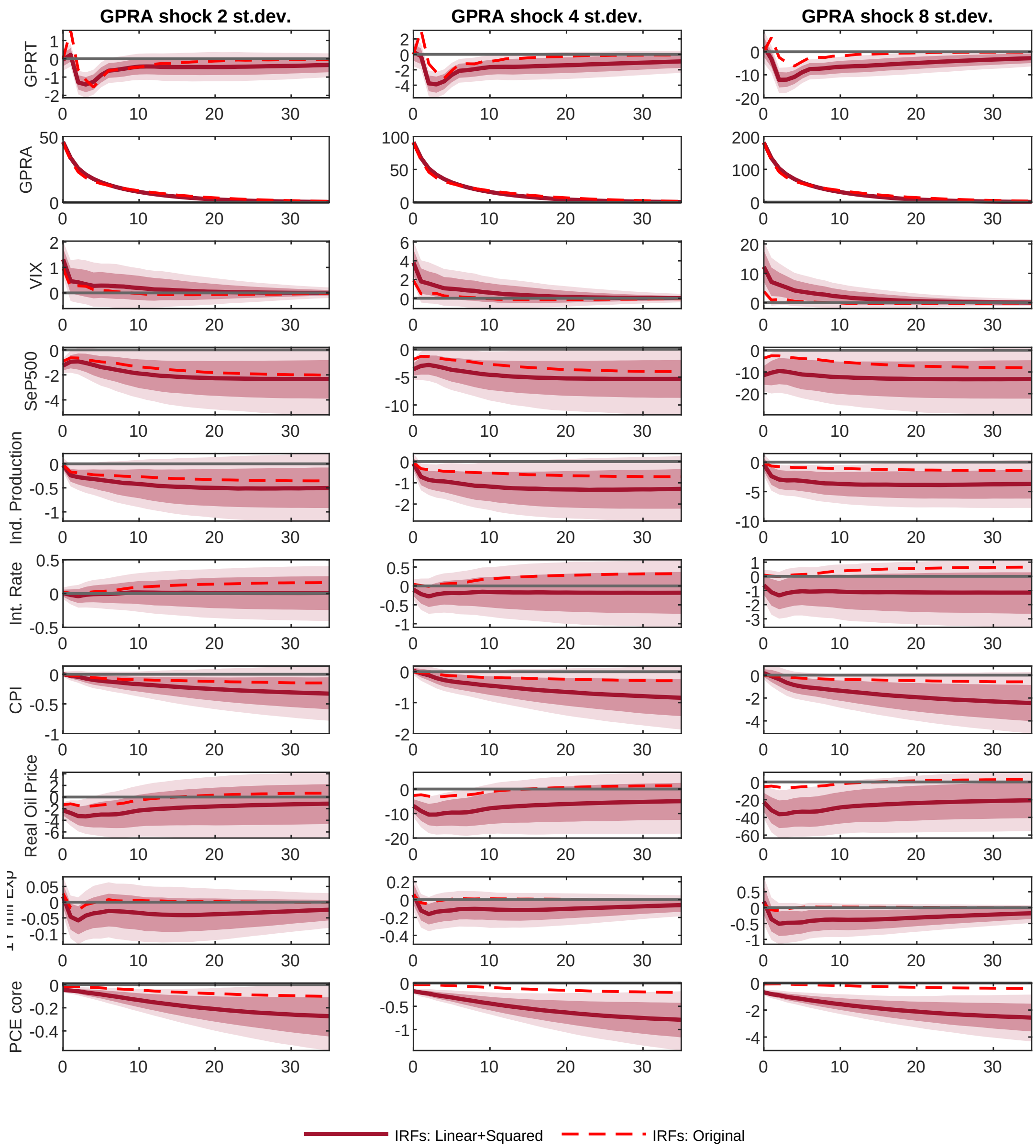
Notes: GPR Acts shocks - all variables included in the model. The solid red line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure C3. GPRT: IRFs of the VARX summing the linear and the non-linear responses to a GPRT shock



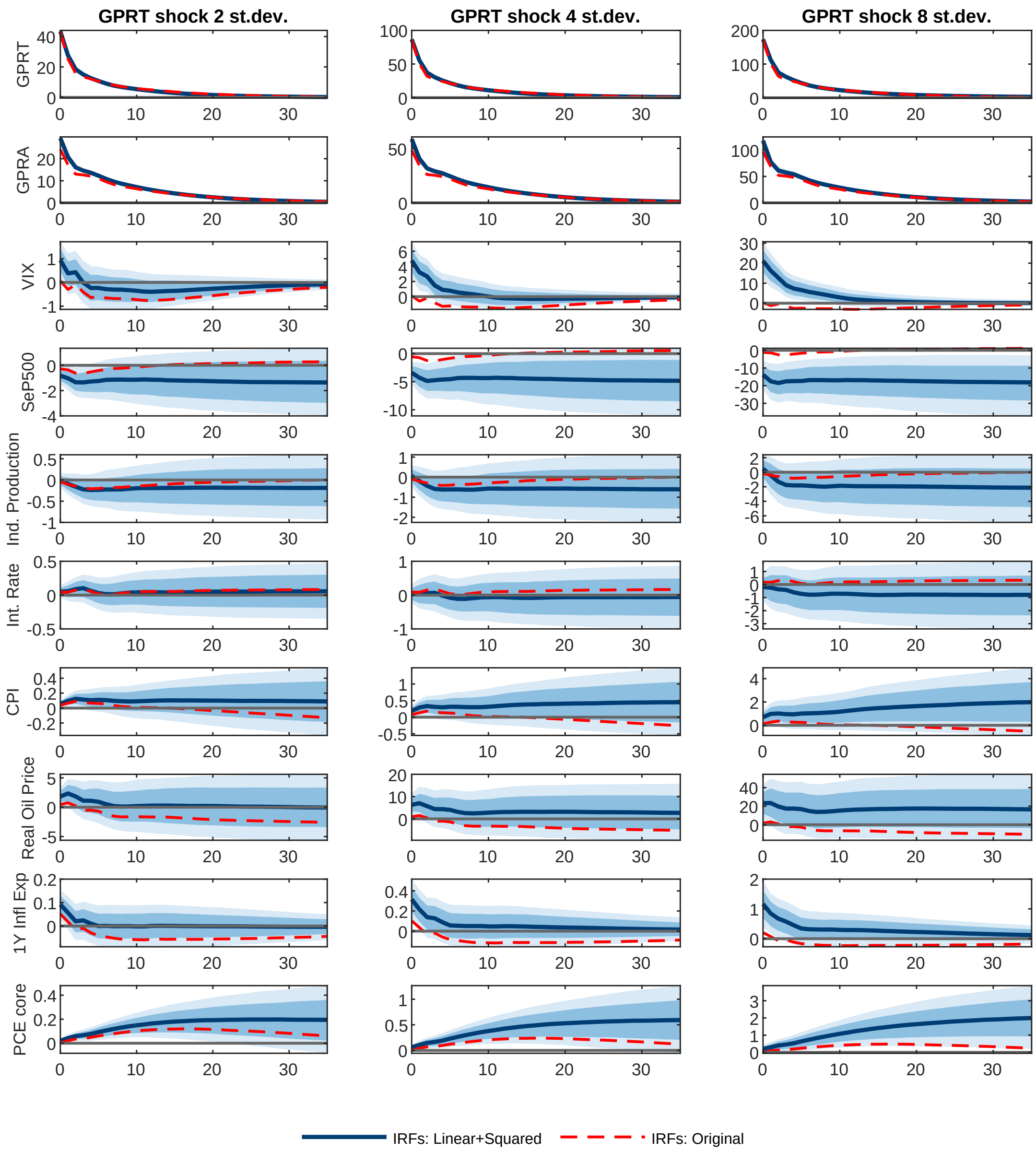
Notes: GPR Threats shocks - all variables included in the model. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure C4. Robustness inverting GPR Acts and Threats order: GPR Acts responses



Notes: GPR Acts shocks with GPR Acts ordered as second in the model. The solid red line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.

Appendix Figure C5. Robustness inverting GPR Acts and Threats order: GPR Threats responses



Notes: GPR Threats shocks with GPR Threats ordered as first in the model. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step SVAR. Each column depicts a different standard deviation of the shock.