Geopolitical risk shocks: When size matters*

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Abstract

We investigate the economic effects of geopolitical risk (GPR) shocks on the US economy, 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 that leads to sharp declines in private demand and equity prices. In contrast, the prices' responses are relatively muted, reflecting the offsetting effects of reduced demand and increasing supply-side pressures. Decomposing GPR into Threats and Acts shocks helps explain this result: Threats shocks behave as second-moment uncertainty disturbances that significantly raise oil prices and inflation expectations, exerting upward pressure on domestic prices, while Acts shocks transmit more similarly to first-moment negative demand shocks.

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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).[1] 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, focusing on the United States, 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 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. Yet, the literature on uncertainty (Caggiano et al., 2015, 2017b; Jackson et al.,

[1] Throughout the paper, we adopt the definition of geopolitical risk in Caldara and Iacoviello (2022): risks associated with wars, terrorist acts, and heightened geopolitical tensions that threaten the peaceful course of international relations. Accordingly, we measure GPR using their news-based index for the US economy.

2020; Chikhale, 2023), financial risk (Alessandri and Mumtaz, 2019; Candelon et al., 2021; Forni et al., 2023b), and news shocks (Forni et al., 2024b) - 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.[2] 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 "wait-and-see" behaviours that delay consumption and investment and, at the same time, interact with financial frictions in a way that amplifies the initial rise in uncertainty (Gilchrist et al., 2014; Alfaro et al., 2024).[3] 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.[4]

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 propose a flexible way to estimate a vector moving average representation of the structural model

[2]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).

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

[4]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.

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.

Our main results point to marked *size non-linearities* linked to GPR shocks. For small shocks, the effects of GPR shocks are not sizable, and a linear model provides a reasonable approximation. For large shocks, the non-linear component becomes quantitatively important, implying that linear models can substantially understate the overall macroeconomic impact. This conclusion is supported by both impulse responses and historical decompositions, which show that non-linear dynamics account for a large share of movements in real and nominal variables during major episodes such as 9/11, the Iraq War, and, to a lesser extent, Russia's invasion of Ukraine.

Importantly, accounting for these non-linearities helps clarify the underlying propagation mechanism of GPR shocks. Our evidence indicates that the amplification is predominantly concentrated in the uncertainty and financial block: when GPR disturbances are large, they trigger disproportionate increases in market-based measures of uncertainty and a tightening in financial conditions, accompanied by sizable declines in equity prices and private demand. To further substantiate this interpretation, we examine the role of alternative propagation mechanisms – highlighted in the literature as salient during major geopolitical episodes – including fiscal policy reactions (Caldara and Iacoviello, 2022) and oil price dynamics (Pinchetti, 2024), and we analyse the response of different variables related to confidence and investment and savings decisions. We also conduct a counterfactual exercise following McKay and Wolf (2023), which shows that muting the non-linear response of uncertainty materially attenuates the amplification, pointing to uncertainty as the primary driver of non-linear transmission, with credit-market frictions playing a complementary role.

Finally, we find that the effects of GPR shocks on prices are mildly positive, although not statistically significant, and exhibit limited non-linearities. We argue that this is due to counteracting effects arising from GPR shocks of different nature. To show this, we apply the same strategy described above to two GPR sub-components: *Acts* and *Threats*. We also augment the baseline specification with variables linked to inflation dynamics to better study how prices respond to these shocks. The analysis shows that *Acts* shocks are akin to first-moment shocks, and are associated with declines in real oil prices and weaker price dynamics, consistent with contractionary demand-type effects. By contrast, *Threats* shocks are closer to second-moment uncertainty shocks and generate significant increases in oil prices, inflation expectations, and both CPI and core inflation. *Threats* shocks also exhibit pronounced size non-linearities, especially for oil prices and inflation expectations, which in turn contribute to stronger inflationary responses at high shock magnitudes.

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. Similarly, Mignon and Saadaoui (2024) show that geopolitical risk shocks are important drivers of oil prices, mainly operating through concerns about supply disruptions. Recent evidence from Verduzco Bustos and Zanetti (2026) also suggests that geopolitical oil price shocks are akin to contractionary oil supply shocks and are often coupled with heightened uncertainty. Existing evidence also points to substantial heterogeneity in the transmission of GPR shocks: effect on prices can be either deflationary or inflationary depending on the relative importance of different supply and demand channels at play (Anttonen and Lehmus, 2025), with sanctions that can amplify inflationary effects in targeted economies such as Russia (Bondarenko et al., 2024). As found in Federle et al. (2024), cross-country effects may also be heterogeneous as spillover from conflicts could depend on geographic proximity. The study from Jalloul and Miescu (2023) examines 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, Sections 3 to 5 present our empirical exercise, and Section 6 concludes.

2 Econometric Approach

We use the econometric approach proposed in Forni et al. (2023b) to study nonlinearities in the effects of a geopolitical risk shock. In this section, we describe the main features of the methodology.[5]

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 $g(u_{gt}) = (u_{gt})^2$.[6]

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:[7]

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

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

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

[5]See also Gonçalves et al. (2021) for a discussion on non-linear regressors in structural dynamic models.

[6]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.

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

and for a two-standard deviation shock are

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

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),[8] vector x_t in Equation (1) admits the following representation:

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

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 identified as the innovation associated with the first variable in a recursive (Cholesky) ordering of x_t, where the geopolitical risk index is ordered first.[9] In practice, the shock is obtained as the difference between the geopolitical risk index

[8] 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.

[9] 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.

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 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.[10] We work with stationary data and take the log-difference transformation of all the real and nominal variables, while the VIX enters the model in levels. The GPR series is instead transformed into log-levels as in Caldara and Iacoviello (2022).[11] This choice does not affect results as shown in Section B, with findings that are robust also with the specification in levels. 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.

As the model is monthly, we include 12 lags. The estimation is performed 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). For the SVAR in the first step, we assume that each series follows an AR(1) process by setting a prior of 0.5 for the reduced-form coefficient on its first lag and zero for the remaining lags.[12] In the VARX, we assume the same priors on the reduced-form coefficients of

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

[11] We also demean our data. As suggested by Bergholt et al. (2023), which helps shrink the volatility around the deterministic component when dealing with the historical decomposition.

[12] 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.

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). Following Bergholt et al. (2023), we also estimate an alternative model specification in level where we include a dummy-initial-observation prior to shrink the uncertainty around the deterministic component, which could be an important factor affecting the historical decomposition.

3.2 The Geopolitical Risk Shock

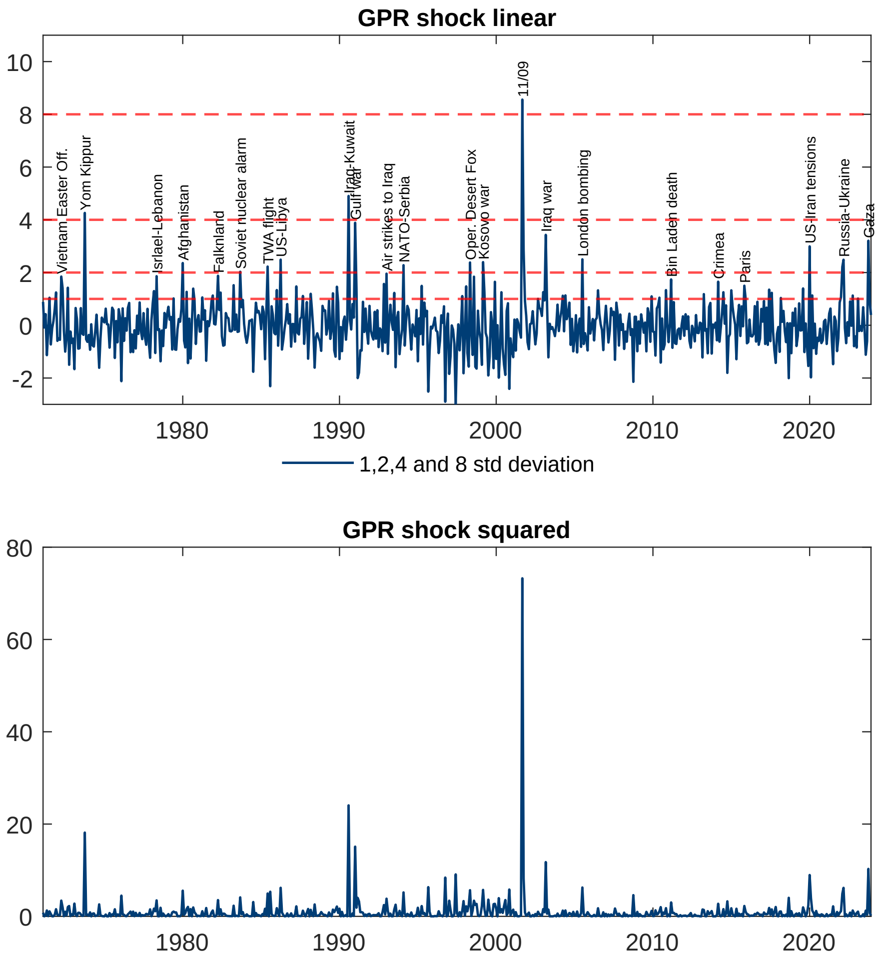
We begin by identifying the geopolitical risk shock as in Caldara and Iacoviello (2022). We then test the identifying assumption that the gth element of $\tilde{\beta}_0$ is equal to zero using a t-test in the regression of the GPR index onto both the shock, its square, and p lags of all the variables. The obtained p-value is larger than 0.1, 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 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. Across the analysed sample, the series surpasses two standard deviations in eighteen episodes. Among these occurrences, 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 follows an intrinsic characteristic of the text-based index developed by Caldara and Iacoviello (2022), which by construction only detects increases in geopolitical risk.[13] This one-sided nature is reflected in our estimated underlying shock and plays an important role in guiding the selection of the non-linearities examined in this study. The literature on non-linearities typically compares the differential effects of positive

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

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.

and negative shocks on the economy, as exemplified by Forni et al. (2023b); Debortoli et al. (2020). However, the scarcity of sizeable negative geopolitical risk shocks, together with the absence of a clear economic interpretation for such events, motivates our focus on non-linearities related solely to the magnitude of positive shocks.

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 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.[14]

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

Figure B2 in Appendix B 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 results resemble those reported in Caldara and Iacoviello (2022) and are consistent with findings presented in Caldara et al. (2022).[15]

A one standard deviation shock to geopolitical risk - corresponding to an increase of the geopolitical risk index by around 20 percent[16] - 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, but its response is also rather insignificant.

Overall, results seem to confirm that (i) a geopolitical shock has an overall negative

[14] 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.

[15] 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.

[16] 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 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.

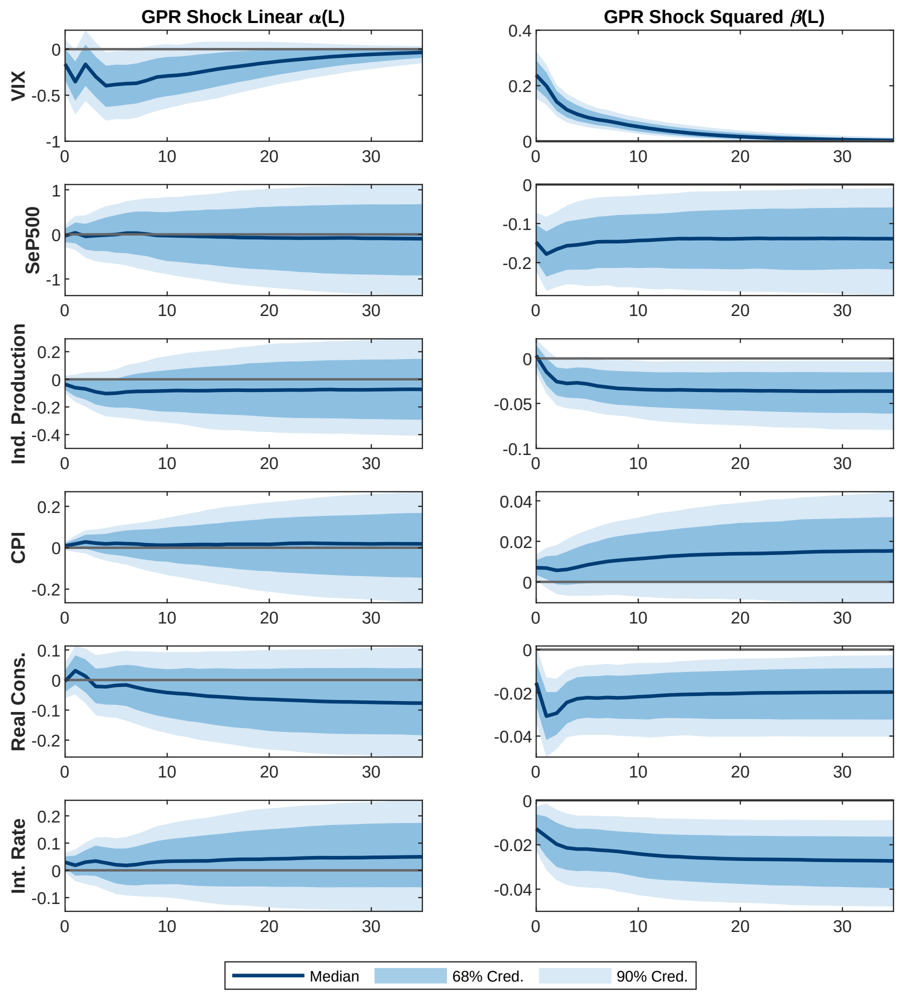
3.3 Disentangling the Role of Non-linearities

Figure 2 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 B2. 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 B2. 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.

The analysis of the IRFs to the non-linear shock - presented in the second column to the right - reveals instead a different story, with responses now predominantly significant across all variables. This indicates that $\beta(L) \neq 0$, and represents a first test that shows 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, which suggests an important role for heightened uncertainty in amplifying the effects of large geopolitical shocks. At the same time, industrial production—and in particular real consumption and equity prices—exhibit sizeable and statistically significant declines. These responses are consistent with an increase in overall uncertainty, which can activate a range of contractionary forces, including delayed consumption and investment decisions, heightened risk aversion, and a deterioration in financial conditions.[17] This hypothesis will be examined more thoroughly in the following sections.

[17]See, among others, Bernanke (1983) on option-value and wait-and-see effects under uncertainty; Kimball (1990) on precautionary behaviour; Bloom (2009) on uncertainty-induced freezes in real activity; and Bayer et al. (2015) on the interaction between uncertainty, precautionary saving, and financial frictions in heterogeneous-agent settings.

Figure 2. 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. Equity prices, Industrial production, Real Consumption and CPI responses are reported as cumulative IRFs.

Finally, while the quadratic shock leads to an increase in CPI inflation, it is also associated with a negative response of the policy rate. Although a full analysis of monetary policy reactions is beyond the scope of this paper, this pattern is consistent with policymakers placing relatively greater weight on stabilizing real activity than on inflation in the aftermath of large geopolitical shocks. A more detailed analysis of price dynamics is provided in Section 5.

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 Section 3.2, especially as the magnitude increases.

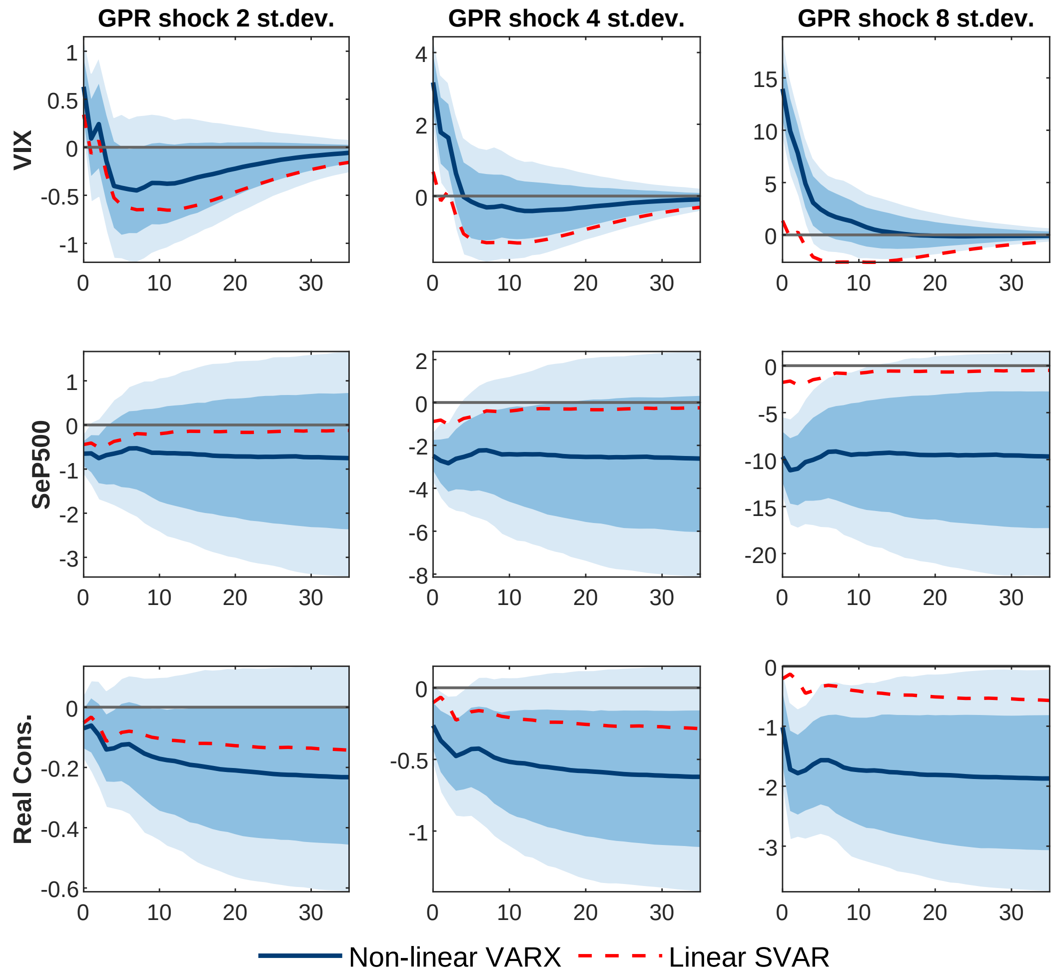
Figure 3 presents the IRFs to a geopolitical shock. Here we focus on a subset of variables included in our model, namely the VIX, S&P 500, and real consumption, which are key indicators for our analysis.[18] We examine the responses to various sizes of positive shocks, guided by the observations made when commenting Figure 1, and we analyse how variables respond to shocks equal to 2, 4, and 8 standard deviations, each reported in a separate column.

The figure plots the median IRFs resulting from the sum of the linear and quadratic components derived from the second-step non-linear VARX (blue solid line), along with the 68% and 90% credible intervals (shaded areas), and with *original* IRFs obtained in the first-step linear SVAR (red dashed line) as depicted in Figure B2. Importantly, both the *second-step* and *first-step* IRFs are rescaled according to the relative magnitude of the analysed shock, which allows a direct comparison 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 some 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 B3 in Appendix B, bring to similar conclusions as the one elucidated in Figure B2. 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, and a linear model is a good approximation of the data generating process.

[18] Figure B3 in Appendix B shows the results for all variables included in the model.

Figure 3. 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. Real consumption and S&P 500 are reported as cumulative IRFs.

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, with the IRFs of the non-linear VARX that now indicate significantly larger responses both at impact and throughout the entire horizon. Specifically, equity prices now exhibit a decline of 3% at impact, compared to a decrease of 0.8% in the first-step linear 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 registers only a marginal (and statistically insignificant) rise of less than 1 point.

To sum up, these findings point to two main observations. First, when geopolitical shocks are of small magnitude, non-linearities do not exert a significant influence on shock transmission, but when the shock increases, non-linearities assume greater importance. Second – and as anticipated in Section 3.3, with increasing magnitude, a new amplification channel is revealed: the VIX increases sharply, and the uncertainty channel becomes highly relevant. This is associated with a set of contractionary forces—including delayed spending decisions, heightened risk aversion, and a deterioration in financial conditions—which amplify the shock's effects through a decline in the S&P500 and real consumption. The relative importance of these mechanisms, and the extent to which uncertainty interacts with financial conditions rather than operating solely through precautionary motives, is explored in more detail in Section 4.

Overall, results emphasize the need to account for non-linearities to accurately assess the impact of GPR shocks on the economy. At the same time, they also highlight that the principal transmission channel for this shock appears to be via heightened *standard* uncertainty channels. This becomes particularly apparent when analysing 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 non-linear VARX, while decreasing equity prices by 10% and real consumption by nearly 2%. Conversely, without accounting correctly 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. As illustrated in Figure B3, other variables now also exhibit notable differences: industrial production declines by around 3% compared to less than 1% implied by the first-step linear SVAR, while the policy rate decreases by around 1.5 percentage point in response to significantly weaker activity.[19]

Finally on prices, their responses reveal a pattern that departs from the standard uncertainty-driven contraction in demand. While activity indicators and financial

[19]Figure B3 also shows that the responses of the GPR index are unchanged between the linear SVAR and the non-linear VARX, thus supporting that the g_{th} element of $\tilde{\beta}_0$ is equal zero, as already discussed in the previous subsection.

variables behave in line with a heightened uncertainty narrative, prices display a modest positive reaction, although statistically insignificant. This result may seem counterintuitive to the idea of uncertainty and precautionary behaviour acting as key channels, which is typically expected to exert downward pressure on prices, and it may indicate the presence of additional mechanisms influencing price dynamics. The interaction between these channels will be explored further in Section 4, while a more detailed analysis of price behaviour specifically will be provided in Section 5.

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.[20] This approach allows us to assess both the *overall* significance of the GPR 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 time series of the non-linear shock, 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.

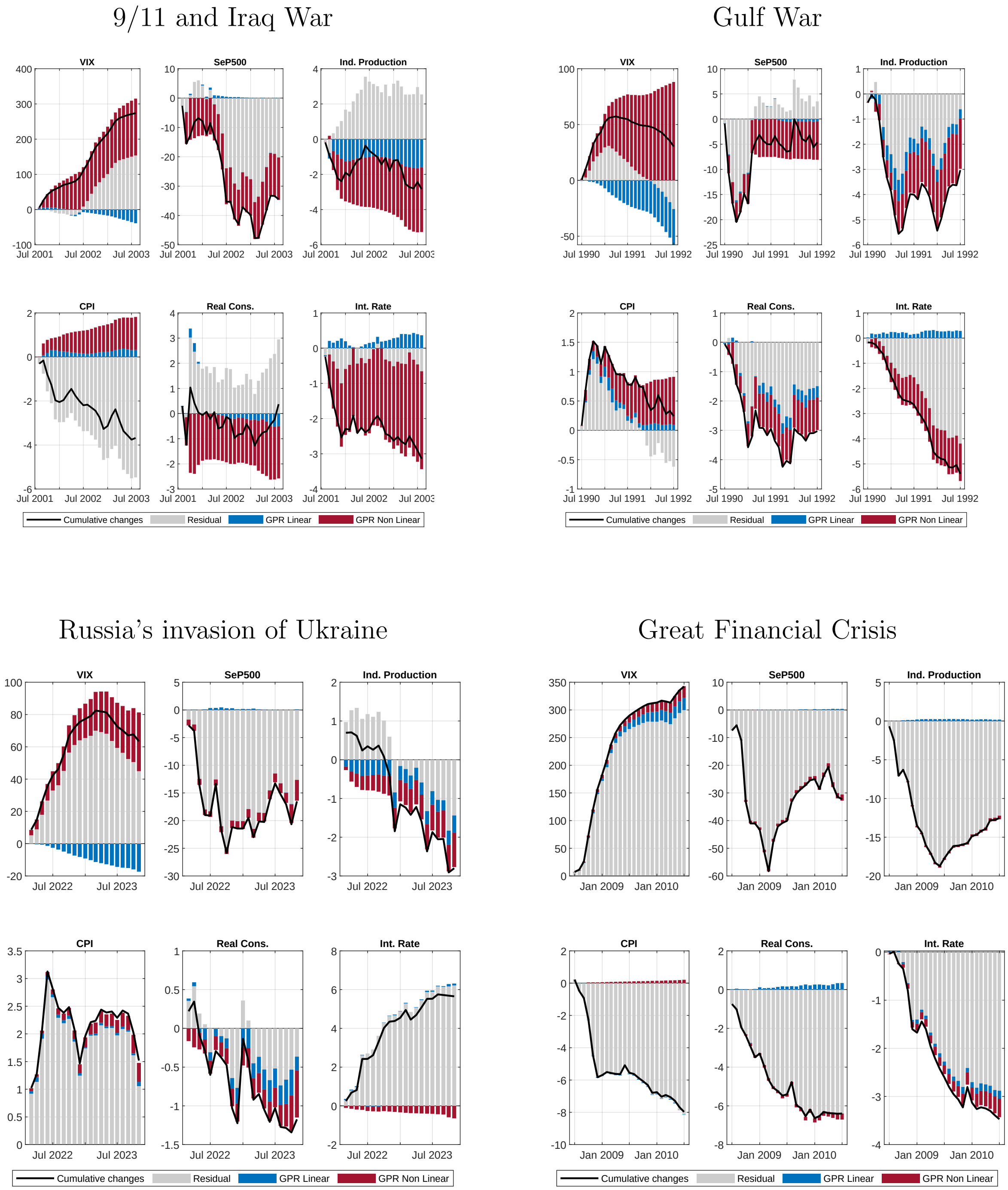
Figure 4 presents the results. The S&P500, real consumption, industrial production, and CPI are depicted as the cumulative sum of the log-changes over the two years from the onset of the selected event, while the VIX and the Fed funds rate are displayed as the cumulative sum (solid black line). The contribution 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 fluctua-

[20] 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.

tions 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

Figure 4. 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.

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 in the US, with the residual shocks explaining most of the fluctuations. This suggests that other factors, such as a broader supply shocks and positive demand shocks, predominantly drove the notable price increases and the subsequent decline in economic activity and financial markets valuations.[21]

In conclusion, these results corroborate what we described in Sections 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

[21] 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)).

which, as highlighted by Caravello and Martinez-Bruera (2024), is well suited to capture size non-linearities. As shown in Figure B4, 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.[22] 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 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 B8. 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 conductthe 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;[23] (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.[24] The corre-

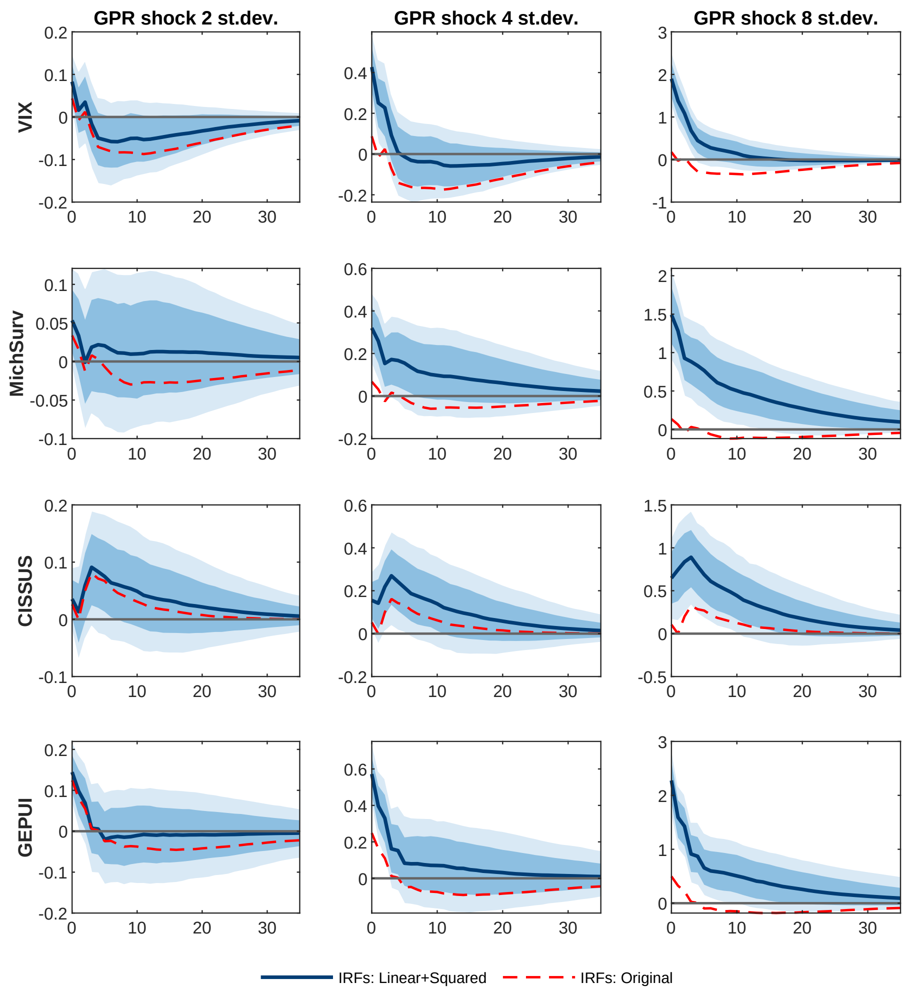
[22] When estimated in log-levels, we set the prior on the coefficients equal to 1.

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

[24] 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.

lation 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 5. 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 shows a different standard deviation of the shock. Each row shows the responses of different measures of uncertainties. All the uncertainty measures are standardized.

Figure 5 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 in magnitude, ranging between 0.2 and 0.6 standard deviations for a 4 standard deviation shock, and between 1 and 2 standard deviations for an 8 standard deviation shock.

4 A Deep Dive in the Propagation Channels

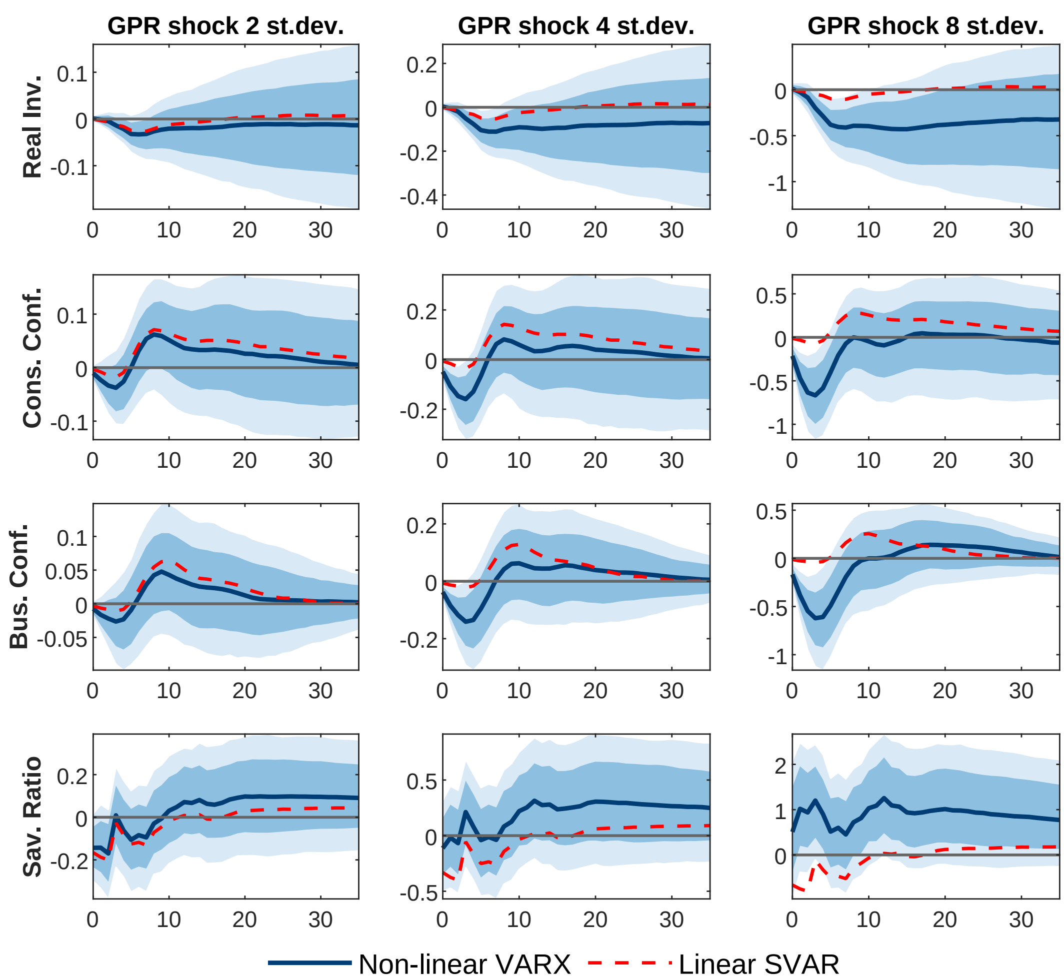
In the previous sections, we argued that the effects of geopolitical risk shocks become disproportionately larger as the magnitude of the shock increases, potentially driven by the uncertainty channel operating through heightened risk aversion. However, these findings may also be consistent with the influence of alternative channels, such as financial frictions and supply disruptions, which can further interact with targeted policy responses, including fiscal spending decisions. This section aims to further discipline the interpretation of these mechanisms.

In Subsection 4.1, we examine the responses of investment, savings and confidence indicators, in order to better assess whether large geopolitical shocks are associated with non-linear declines in investment activity and in the confidence of both households and firms – patterns consistent with delayed decision-making under heightened uncertainty. In Subsection 4.2, we instead augment the baseline VAR with variables capturing fiscal policy and oil prices, two dimensions that the literature has identified as being closely linked to geopolitical risk episodes (see, among others, Caldara et al., 2022 on fiscal responses and Pinchetti, 2024 on energy markets). We also add an indicator of financial conditions to study how our results interact with financial frictions. This allows us to assess whether the non-linear dynamics documented in the baseline specification are still valid once the omitted channels are explicitly considered in our model. Finally, in Subsection 4.3, we conduct a counterfactual analysis to evaluate whether the non-linear amplification of large GPR shocks persists when the propagation through uncertainty is muted, providing additional evidence on the role of uncertainty relative to alternative transmission mechanisms.

4.1 The Responses of Investment and Confidence indices

To further investigate the mechanisms through which large geopolitical risk shocks propagate, we augment the baseline VAR with a set of variables that are informative about firms' and households' decision-making under uncertainty. In particular, we include real investment, consumer confidence, business confidence, and the saving rate. Through the analysis of their responses, we can better analyse whether the non-linear amplification documented in the baseline specification is associated with delayed investment decisions, deteriorating confidence, and precautionary balance-sheet adjustments. Variable definitions, sources, and transformations are reported in Table A2 in Appendix A.

Figure 6. Impulse Response Functions of Real Investment, Saving rate and Confidence indices



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 shows 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. Real investments are reported with cumulative IRFs.

Figure 6 reports the impulse responses to geopolitical risk shocks of increasing magnitude (2, 4, and 8 standard deviations), comparing the non-linear VARX responses with those implied by the linear SVAR. Results provide clear evidence that non-linearities become increasingly relevant as the size of the shock increases. For relatively small shocks, responses are muted and broadly comparable across the two specifications. In contrast, for larger shocks, investment declines markedly more in the non-linear model, while both consumer and business confidence display sharp drops – peaking after four to five months – that are largely absent in the linear specification.

The saving rate response is also consistent with households adjusting their balance sheets in response to heightened risk and uncertainty. While it reacts non-significantly (and partially negatively) to small shocks, it changes sign as the shock size increases, also exhibiting marked non-linearities. Taken together, these patterns suggest that large geopolitical shocks are associated with a deterioration in confidence and a postponement of spending and investment decisions – features commonly associated with "wait-and-see" behaviours under uncertainty.

These results should not be interpreted as uniquely identifying precautionary motives as the sole driver of the observed dynamics. The contraction in investment and the rise in saving may also reflect other forces that become more salient in periods of elevated uncertainty, including tighter financial conditions or balance-sheet constraints. Nonetheless, the evidence in this subsection supports the view that heightened uncertainty plays a central role in shaping the non-linear transmission of large geopolitical risk shocks by depressing confidence and amplifying contractionary responses in private demand.

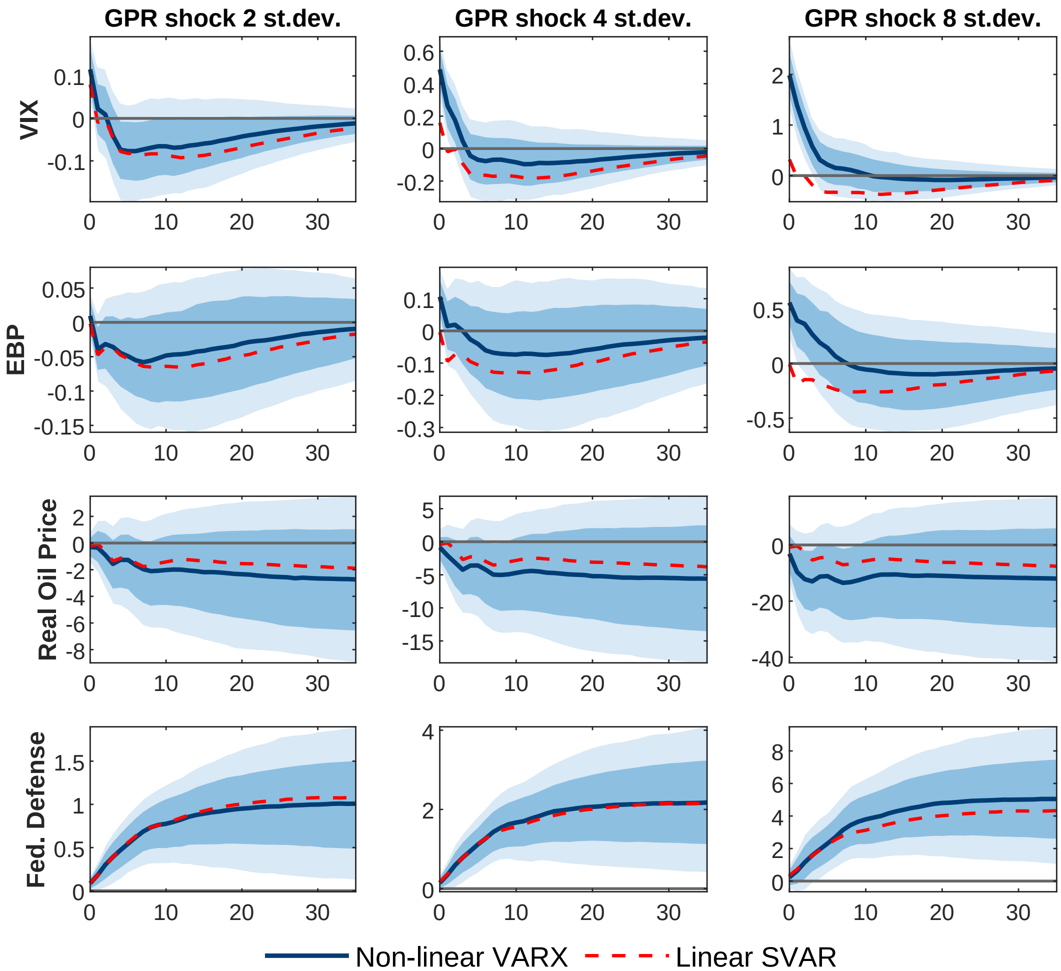
4.2 Controlling for Additional Transmission Channels

To address concerns that other channels may explain part of the transmission of large geopolitical risk shocks, we further augment the VAR with variables capturing fiscal policy and energy markets dynamics – which have been highlighted in the literature as being closely linked to geopolitical risk episodes. Specifically, we include a fiscal variable, capturing the discretionary response of government spending, and real oil prices.[25] We also include the Excess Bond Premium (EBP, from Gilchrist et al., 2014) as a proxy for financial conditions that can help us shed light on the role of financial frictions and first-moment financial shocks in transmitting GPR shocks.

Figure 7 reports the impulse responses to geopolitical risk shocks of increasing

[25]Variable definitions, sources, and transformations are reported in Table A2 in Appendix A.

Figure 7. Analysing other Channels: Fiscal, Real Oil prices and EBP



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 shows 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. Federal defense spending and Real oil prices are reported with cumulative IRFs.

magnitude. Consistent with the findings in Caldara and Iacoviello (2022), fiscal policy reacts countercyclically, with government spending increasing following a GPR shock. This fiscal expansion is, however, not sufficiently large to offset the contractionary effect of the shock in the private sector of the economy, as private consumption, industrial production, and equity prices all decline sharply as in the baseline specification, implying that aggregate demand weakens despite the fiscal response. Interestingly, fiscal policy does not exhibit significant non-linearities, as the responses do not increase disproportionally with large shocks, and therefore do not influence the amplification mechanism discussed so far. Yet, fiscal responses may help explain partially why CPI prices react positively, although this reaction remains statistically insignificant, as in the baseline specification (see additional IRFs in Appendix C, Figure C1)

Turning to real oil prices, we find that they decline following a GPR shock, although the response is not statistically significant. This suggests that oil price movements are not the primary driver of the non-linear real-side responses documented above. This result may appear surprising given the close association between geopolitical risk and energy markets—and given the response of prices in our model. In Section 5, we therefore examine in details whether these findings may mask confounding effects on oil prices and inflation arising from offsetting forces associated with different components of geopolitical risk shocks.

Finally, the EBP exhibits a non-linear response pattern similar to that of the VIX, although its magnitude is smaller (both variables are standardised). This suggests that financial frictions may interact with heightened uncertainty to amplify the contractionary effects of large geopolitical shocks. In particular, tighter credit conditions may reinforce the drop in investment and other interest-sensitive components of demand, consistent with the mechanisms emphasized by Alfaro et al. (2024). At the same time, the similarity in the responses of EBP and VIX underscores some challenges in cleanly separating uncertainty from financial conditions in periods of elevated risk, a point we return to explicitly in the counterfactual analysis that follows.

4.3 Switching Off Uncertainty: A Counterfactual Exercise

While the previous subsections document that large GPR shocks are associated with sharp non-linear increases in uncertainty and pronounced contractions in real and financial activity, this evidence alone does not establish that uncertainty is the key propagation mechanism. To further discipline the interpretation, we conduct two counterfactual exercises designed to selectively mute non-linear amplification channels.

In the first counterfactual, we focus on uncertainty as proxied by the VIX. The objective is to assess whether the variables analysed in the previous sections continue to display amplified dynamics once the uncertainty channel is muted. Methodologically, we follow McKay and Wolf (2023) and impose that the VIX does not respond to the geopolitical risk shock, while leaving all other estimated dynamics unchanged.[26] To implement the restriction, we use a set of second-moment shocks commonly employed in the literature: the uncertainty shocks of Piffer and Podstawski (2018) and Caldara et al. (2016), two uncertainty shocks extracted from the macro and financial uncertainty indices of Jurado et al. (2015), and the VIX shock from the SVAR estimated in Section 3. Importantly, we restrict only the non-linear component of the VIX response, leaving the linear transmission unchanged. As a result, the counterfactual isolates the role of uncertainty-driven non-linear amplification rather than mechanically altering the baseline propagation of GPR shocks.

The left-hand column of Figure 8 presents the responses to a GPR shock of four standard deviations – a magnitude that, as shown in previous sections, exhibits marked non-linear dynamics. As in the previous sections, the solid blue line reports the non-linear VARX responses, while dashed red line the those of the linear SVAR. Finally, the grey line with diamonds shows the counterfactual paths obtained when the non-linear response of the VIX is suppressed. This allows us to have a direct comparison, as any divergence between the blue and grey lines would represent the contribution of uncertainty to the propagation of large GPR shocks.

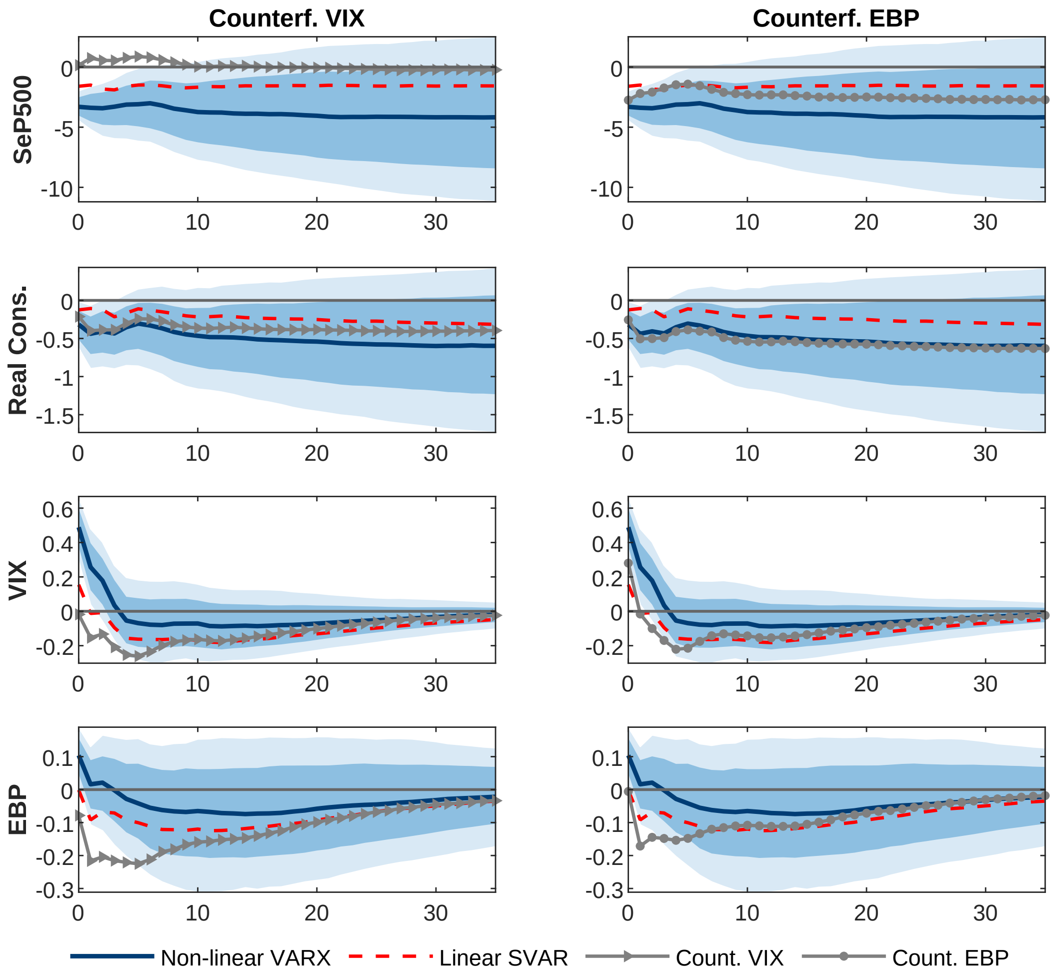
Once the non-linear response of the VIX is muted, the amplification of real and financial variables is markedly reduced. Equity prices exhibit counterfactual responses that are substantially attenuated and even display an opposite sign relative to the linear SVAR benchmark, while real consumption closely tracks the linear SVAR response. This indicates that much of the divergence between linear and non-linear dynamics operates through the endogenous response of uncertainty. Results for the remaining variables are shown in Figure C2 in Appendix C. Remarkably, industrial production also shows a similar behaviour, barely responding once the uncertainty channel is switched off.

In the second counterfactual, we instead explore the interaction between uncertainty and credit market frictions by muting the non-linear response of the EBP. The exercise mirrors the previous one but uses a set of shocks associated with first-moment financial disturbances: the financial shock of Forni et al. (2024a), the news shock of Piffer and Podstawski (2018), and the EBP shock from the SVAR estimated section 3.[27]

[26] A closely related exercise is performed by Forni et al. (2025), who switch off the uncertainty channel in the context of oil news shocks.

[27] We do not perform analogous counterfactuals for fiscal policy and oil prices, as these variables display comparatively muted non-linearities, as shown in the previous subsection. Furthermore, in

Figure 8. Counterfactual exercise



Notes: The left-hand side column shows results of the first counterfactual exercise, where the non-linear VIX response is switched off, while the right-hand side column shows results for the second counterfactual exercise, where the non-linear EBP shock is switched off. In both cases, responses coincide with a GPR shock equal to four standard deviations. The solid blue line represents the median response of the overall linear and non-linear dynamics estimated in the second step, while the shaded bands denote the 68% and 90% credible intervals. The dashed red line shows the responses from the first-step SVAR. The grey line shows the counterfactual impulse responses. Real consumption and S&P 500 are both reported as cumulative IRFs.

The results of the second counterfactual exercise are reported in the right-hand column of Figure 8. While the counterfactual successfully dampens the non-linear response of the EBP, the VIX responds positively, indicating that the two channels can be at least partially disentangled. In contrast to the VIX counterfactual, muting EBP non-linearities produces a more limited reduction in amplification. Equity prices now

the case of fiscal policy, the variable exhibits a countercyclical behaviour, and would then tend to dampen, rather than amplify, the contraction.

lie between the linear SVAR and non-linear VARX responses, while real consumption is essentially unaffected.

Taken together, these counterfactuals point to uncertainty as the primary driver of non-linear amplification following large geopolitical risk shocks. Credit market frictions, while relevant, appear to play a secondary and complementary role, amplifying the effects of uncertainty rather than acting as an independent source of non-linearity.

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

Results so far show mild positive price responses to aggregate GPR shocks and limited asymmetries across shock magnitudes. This relatively muted response could be consistent with confounding effects coming from different channels, and from the fact that GPR shock could also capture events of various natures that may cause different dynamics in the response of prices.

In this section, we use the two indices proposed by Caldara and Iacoviello (2022) – the Geopolitical Threats (GPRT) index and the Geopolitical Acts (GPRA) index – to better understand price dynamics. More specifically, we ask whether the materialisation of geopolitical events (GPRA) behaves more like a first-moment contractionary shock – akin to a demand-type disruption – while news about potential future disruptions (GPRT) operates primarily through second-moment uncertainty, particularly via channels affecting energy markets and inflation expectations.[28]

If this hypothesis is correct, Acts and Threats may have contrasting effects on prices. In particular, GPRA shocks could exert downward pressure on prices, reflecting their contractionary demand effects, whereas GPRT shocks may instead push prices upward, primarily through increases in energy prices.[29]

To test this hypothesis, we follow the same strategy described in previous sections, but with a fundamental modification as we incorporate both the GPRA and GPRT indices in our baseline model 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. Consistent with the approach adopted by Caldara and Iacoviello (2022), the identification scheme imposes a configuration of shocks whereby

[28] It is important to note, however, that the literature stresses that uncertainty is endogenous and may increase in both cases (Ludvigson et al., 2021).

[29] 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 these two components.

GPRA shocks can induce contemporaneous movements in both acts and threats, whereas GPT shocks correspond to threat-specific disturbances that do not materialize into acts within the same month.[30] In other words, we can distinguish pure threat shocks from act shocks: the former reflect unmaterialized threats, whereas the latter correspond to realized events that amplify uncertainty through their materialization.

Additionally, as our focus is on prices, we add three more variables to the baseline SVAR described in Section 3: 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 real oil prices as previous studies have shown that they are largely affected by geopolitical risk episodes (see, for instance, Pinchetti, 2024 and Mignon and Saadaoui, 2024). We consider a measure of inflation expectations to study potential changes in consumers' views about the future development of inflation, capturing an additional channel 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.[31]

We then implement a two-step strategy akin to the one adopted in Section 3: we estimate an SVAR model that does not account correctly 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 1978M1 as this is the first available observation for the one-year ahead inflation expectation variable.

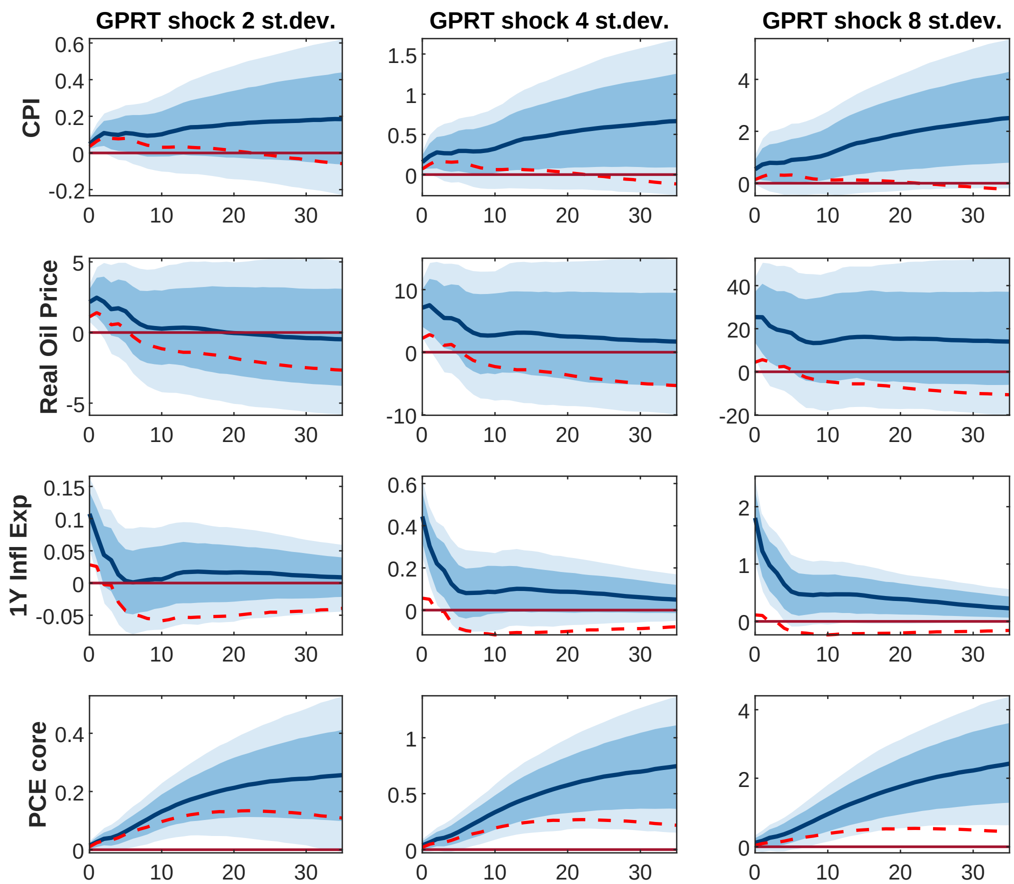
Our description of the results focuses on the responses of price measures, while the remaining IRFs can be found in Appendix D. We start with the responses to a GPRT shock. Figure 9 illustrates in three distinct columns the IRFs following respectively a 2, 4 and 8 standard deviations shock. Again, the 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

[30] In the robustness section in Appendix D, we also explore an alternative ordering with the GPRT preceding the GPRA index.

[31] As described in Section 4, fiscal spending could also explain why prices increase following GPR shocks. Therefore, we also add the measure of fiscal spending used in that section to control for this channel when we disentangle GPR into Acts and Threats components.

responses from a simple linear SVAR model.

Figure 9. 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 shows a different standard deviation of the shock. IRFs are rescaled according to the relative magnitude of the analysed shock in both cases. Variables are reported with the cumulative IRFs except for the 1Y-ahead inflation expectations.

As evident from Figure 9, GPR Threats shocks have a non-trivial effect on the inflation components. The analysis of the IRFs uncovers two possible complementary channels that can explain this result: the cost-push shock due to the 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 core is initially slower to react but, towards the third year, it shows 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.

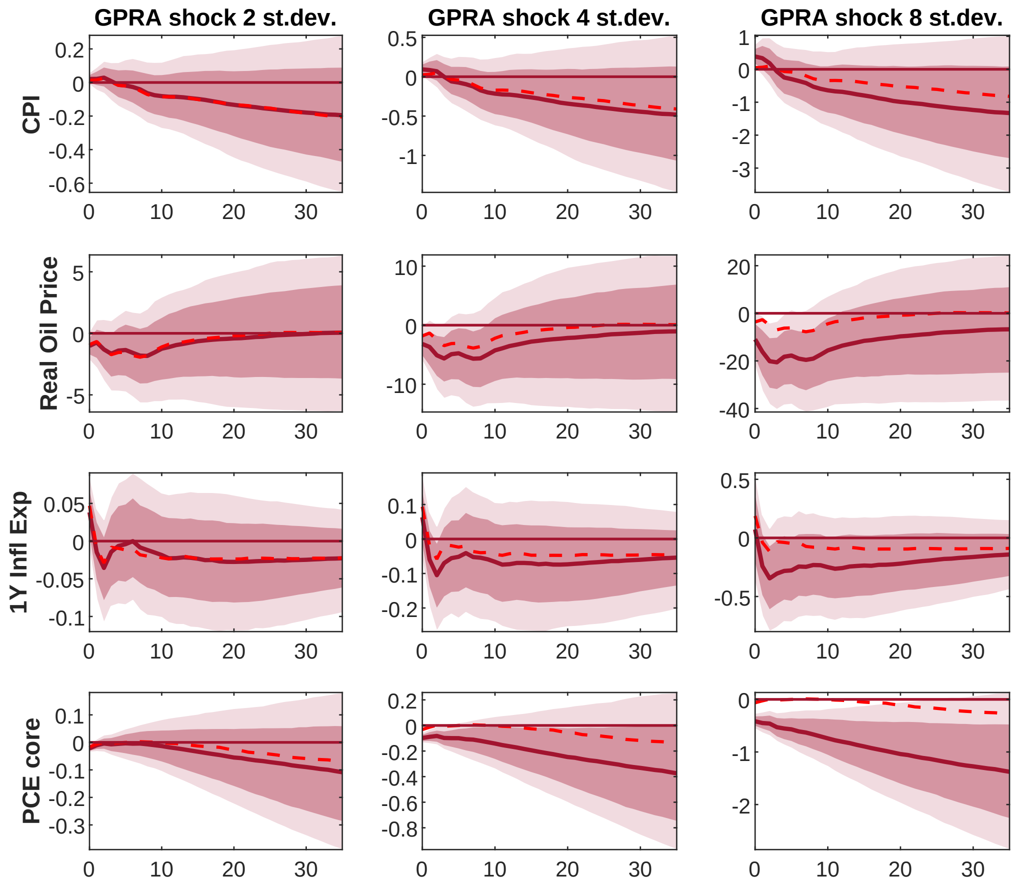
Results are also complemented by the analysis of non-linearities, which arise already with just a two standard deviation shock and become particularly evident at four and eight standard deviations. Importantly, non-linearities affect all the inflation indices we include in the model. Non-linearities 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, and aligns with findings in the literature on oil prices (Mignon and Saadaoui, 2024; Kilian and Murphy, 2014; Juvenal and Petrella, 2015; Cross et al., 2022; Verduzco Bustos and Zanetti, 2026). 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), who show that firms could adopt an upward pricing (precautionary pricing) bias behaviour in response to uncertainty shocks to ensure themselves against future states characterized by high future marginal costs.

Figure 10 reports instead 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. 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. Moreover, 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 suggests that GPR Acts shocks transmit more similarly to a first-moment shock, while GPR Threats shocks are closer to second-moment uncertainty shock. This is in line with the interpretation that non-linearities are mostly a consequence of higher uncertainty not directly captured by the GPR Acts index, while in the case of GPR Threats shock, uncertainty fuels a higher precautionary demand for oil, that consequently transmits

Figure 10. 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 shows a different standard deviation of the shock. IRFs are rescaled according to the relative magnitude of the analysed shock in both cases. Variables are reported with the cumulative IRFs except for the 1Y-ahead inflation expectations.

into domestic inflation also via an increase of inflation expectations.[32] The two mechanism have opposite effects on prices, which can explain the relatively muted response of CPI to a generic geopolitical risk shock.[33]

The analysis highlights that GPR shocks capture a multifaceted phenomenon and that policymakers need to know the exact reason behind the increase of geopolitical

[32]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).

[33]Results are not explained by the fiscal spending channel, as the variable displays statistically insignificant responses following a GPRT shock, and positive responses following a GPRA shock, as visible in Figure D2 and D5.

risk to design an adequate policy response. This may have important implications for modelling, as our Threats–Acts evidence supports treating measured geopolitical risk as a composite disturbance, rather than as a single primitive "demand" or "supply" shock. In particular, Threats shocks can be represented as a second-moment (uncertainty/volatility) shock interacting with an oil/energy-risk block, while Acts shocks are closer to a first-moment contractionary demand-type shock, albeit with uncertainty rising endogenously as well.

This mapping also helps discipline which frictions are required to match the joint behaviour of prices and real activity and underline that GPR shocks are different than "standard" uncertainty shocks. In many benchmark models, uncertainty shocks propagate like aggregate-demand shocks and tend to be disinflationary Leduc and Liu (2016). Therefore, generating positive inflation responses requires an additional nominal or markup mechanism and/or an energy-cost channel. Non-linear DSGE models with nominal rigidities provide one such mechanism: uncertainty can induce an upward bias in markups ("precautionary pricing"), raising inflation even as activity contracts (Fernández-Villaverde et al., 2015; Born and Pfeifer, 2017; Andreasen et al., 2024). Finally, heterogeneous agents and financial and credit frictions can also materially amplify uncertainty-type disturbances and potentially help rationalize the large real and financial responses we document at high shock magnitudes (Bonciani and van Roye, 2016; Cesa-Bianchi and Fernandez-Corugedo, 2014).

6 Conclusion

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

We highlight the importance of considering non-linearities 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: as the magnitude of the shock increases, uncertainty spikes and is accompanied by sizeable contractions in equity prices, real consumption, and investment. These patterns are consistent with a broad set of contractionary forces typically associated with heightened uncertainty—including delayed spending decisions, increased risk aversion, and a deterioration in financial conditions—rather than with a single, narrowly defined mechanism. Counterfactual evidence further supports the view that the uncertainty channel plays a central role in driving the observed non-linear amplification, even though other channels may continue to contribute at the margin.

We also delve into the effect of GPR shocks on prices. We find that prices respond positively to the GPR 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 shocks as they decrease prices and are subject to only limited non-linearities when the size of the shock increases. Conversely, GPR Threat shocks display significant non-linearities, are akin to second-moment uncertainty shocks, and cause prices to increase.

Taken together, our 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, while 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 properly calibrate their policy response to safeguard economic and financial stability.

Several avenues for future research remain open. For instance, extending the analysis to other advanced economies would help assess the generalisability of our findings, as the transmission of GPR shocks is likely to vary across countries depending on their exposure to conflict areas, energy dependence, and fiscal policy frameworks. Moreover, analysing disaggregated price data would allow to better identify which sectors are most sensitive to geopolitical risk and to disentangle the relative contribution of each transmission channel documented in this paper. We leave these extensions for future work.

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A Appendix

Appendix Table A1. Geopolitical Events Corresponding to Shock Episodes

Episode	Description
Vietnam War: Easter Offensive	Attack by the North Vietnamese Army (April 7, 1972) on the South Vietnamese city of An Loc as part of the 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), in which a malfunction nearly triggered a nuclear response.
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	Coalition airstrikes against Iraq, largely related to the enforcement of the no-fly zone in southern Iraq.
NATO–Serbia	The NATO bombing of Yugoslavia (March–June 1999) during the Kosovo War, aimed at halting human rights abuses.
Oper. Desert Fox	Operation Desert Fox (December 16–19, 1998), US and UK airstrikes targeting Iraqi military and 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.

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Episode	Description
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 theatre.
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: description, source, and transformation

Variable	Description	Source	Transformation
Geopolitical risk measures			
GPR; GPRT; GPRA	Geopolitical Risk Ind	Caldara and Iacoviello (2022)	$\log(x) \times 100$
Real activity			
Ind. Production	Industrial Production Index	Federal Reserve Board	$\Delta \log(x) \times 100$
Real Cons.	Real Consumption Expenditure	Bureau of Economic Analysis	$\Delta \log(x) \times 100$
Real Inv.	Real Private Fixed Investment (per capita)	Bureau of Economic Analysis	$\Delta \log(x) \times 100$ *(quadratic interpolation)*
Prices and inflation expectations			
CPI	Consumer Price Index (All Urban Consumers)	Bureau of Labor Statistics	$\Delta \log(x) \times 100$

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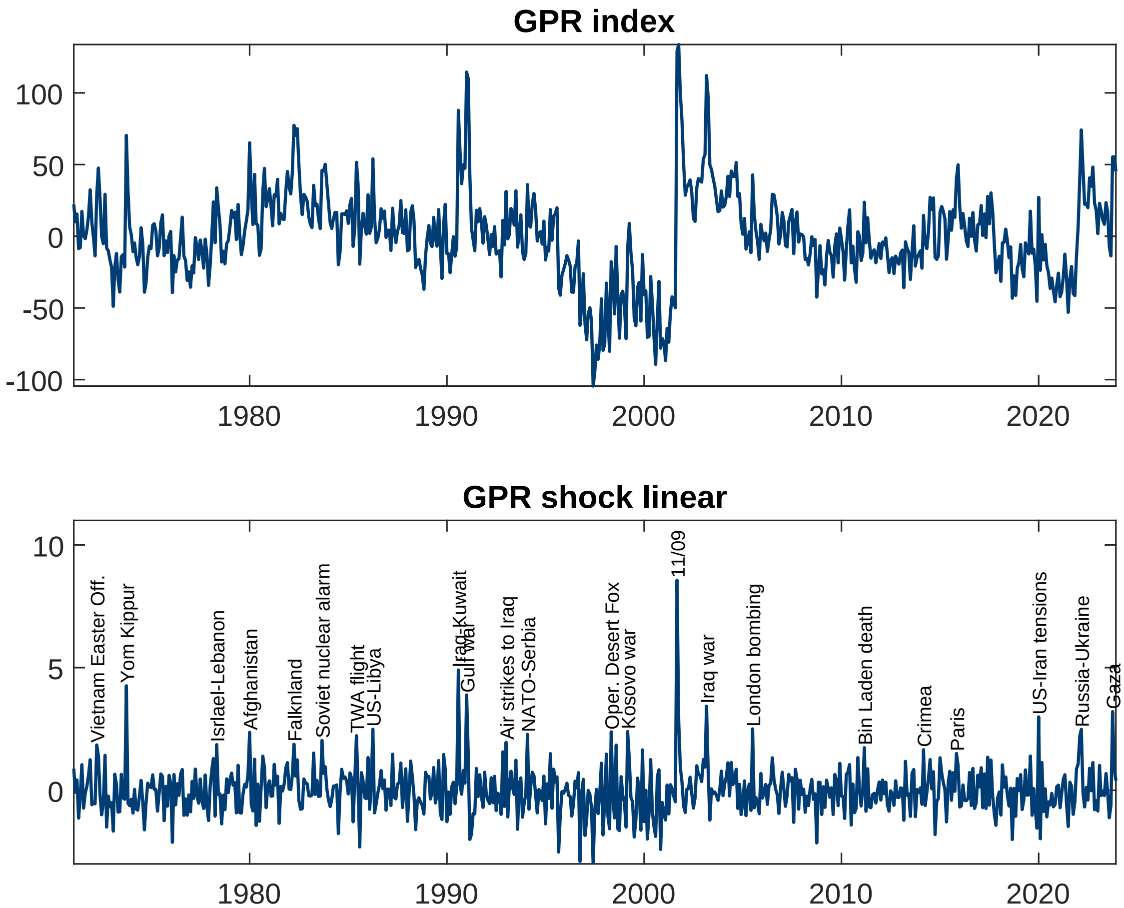
Variable	Description	Source	Transformation
PCE core	PCE excluding Food and Energy	Bureau of Labor Statistics	$\Delta \log(x) \times 100$
1Y $E(\pi)$	Expected inflation, one year ahead	University of Michigan	Levels
Real oil price	WTI oil price deflated by CPI	Energy Information Admin. and Chicago Mercantile Exchange	$\Delta \log(x) \times 100$
Financial conditions and asset prices			
S&P500	S&P 500 Index deflated by CPI	Standard & Poor's	$\Delta \log(x) \times 100$
VIX	Implied equity market volatility	Chicago BoardOptionsExchange	Levels
EBP	Excess Bond Premium	Gilchrist and Zakrajšek (2012) / Federal Reserve Board	Levels
Int. Rate	Federal Funds Rate	Federal Reserve Board	Levels
Confidence and savings			
Cons. Conf.	Consumer Confidence Index	Conference Board	Levels
Bus. Conf.	Business Confidence Index (ISM PMI / NFIB)	FRED	Levels
Saving Rate	Personal Saving Rate	Bureau of Economic Analysis	Levels
Fiscal variables			
Def. Spend.	National Defense Consumption Expenditure and Gross Investment	Bureau of Economic Analysis	$\Delta \log(x) \times 100$ *(quadratic interpolation)*

Note: All variables are sourced via Haver Analytics or FRED. The Federal Funds Rate is augmented with the U.S. shadow rate of Wu and Xia (2016) when the policy rate is at the effective lower bound. Investment and defense spending are quarterly variables converted to monthly frequency using quadratic interpolation.

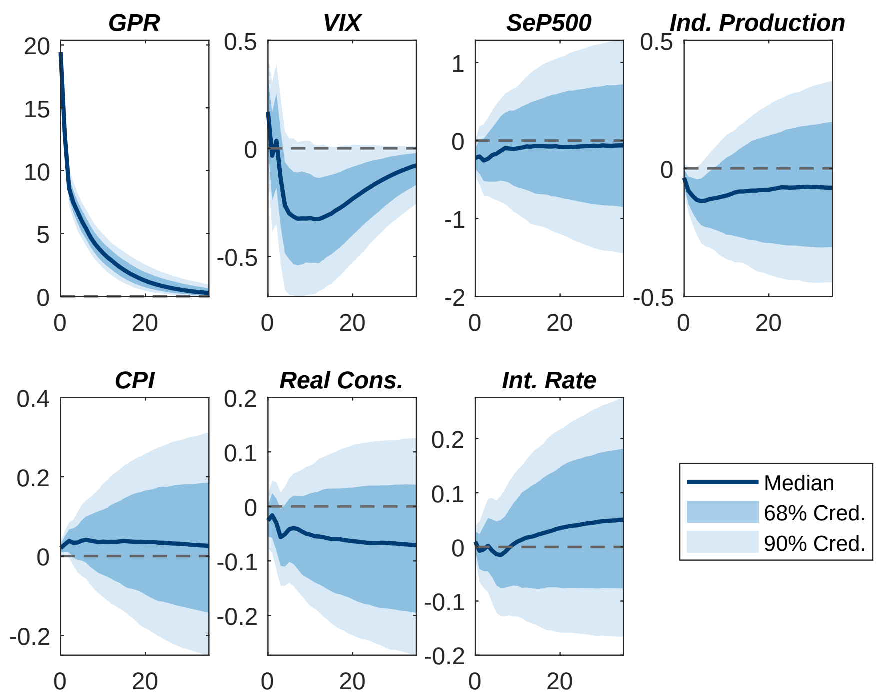
B Appendix: Robustness and Additional Figures

Appendix Figure B1. GPR index vs linear shock



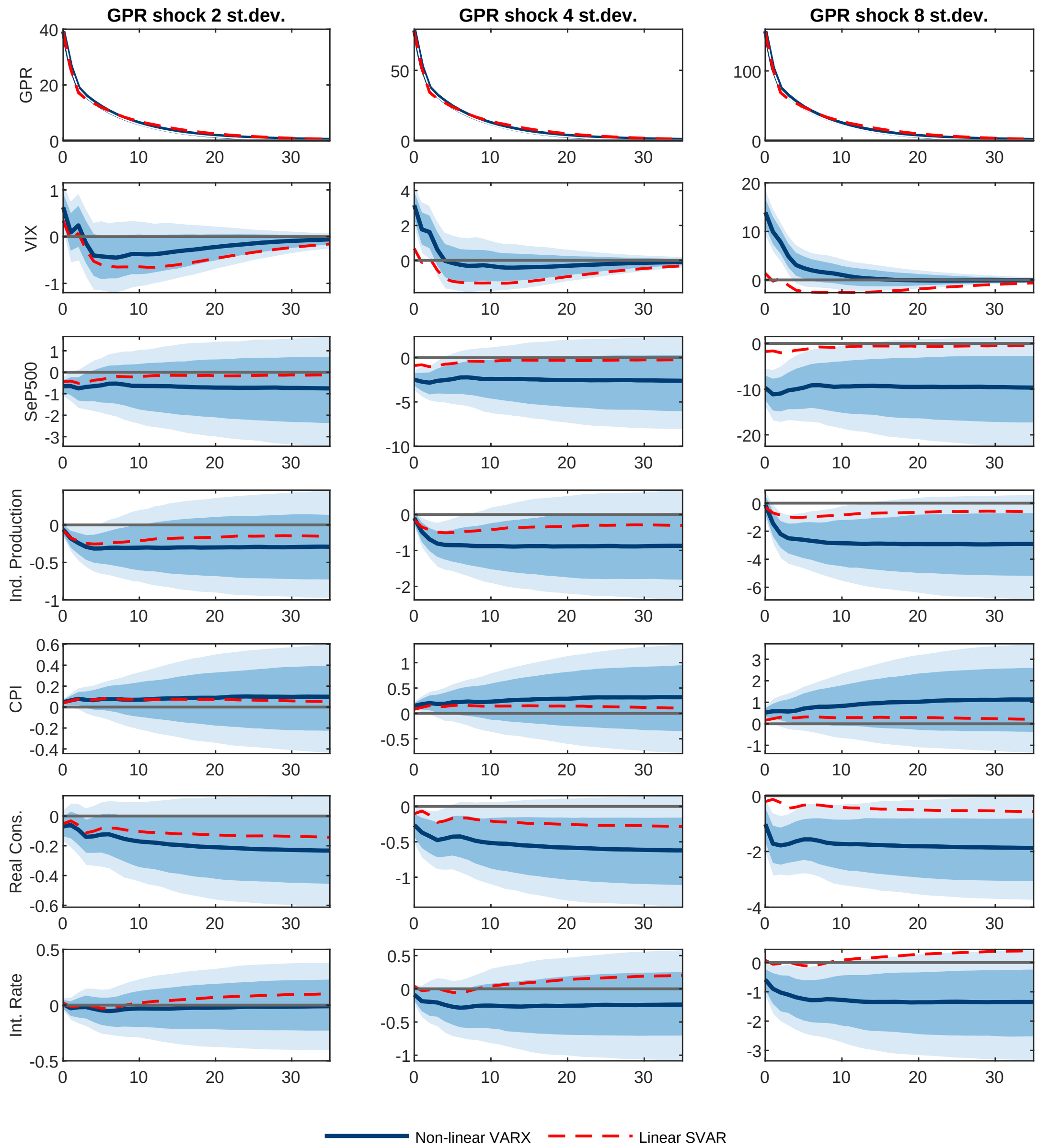
Notes: Geopolitical shock index (top panel) along with the shock estimated in the linear SVAR model (bottom panel). Positive values correspond to an increase in Geopolitical Risk. Labels refer to particularly large geopolitical events and are described more extensively in table A1 in Appendix A.

Appendix Figure B2. The Impact of GPR shock in the linear SVAR



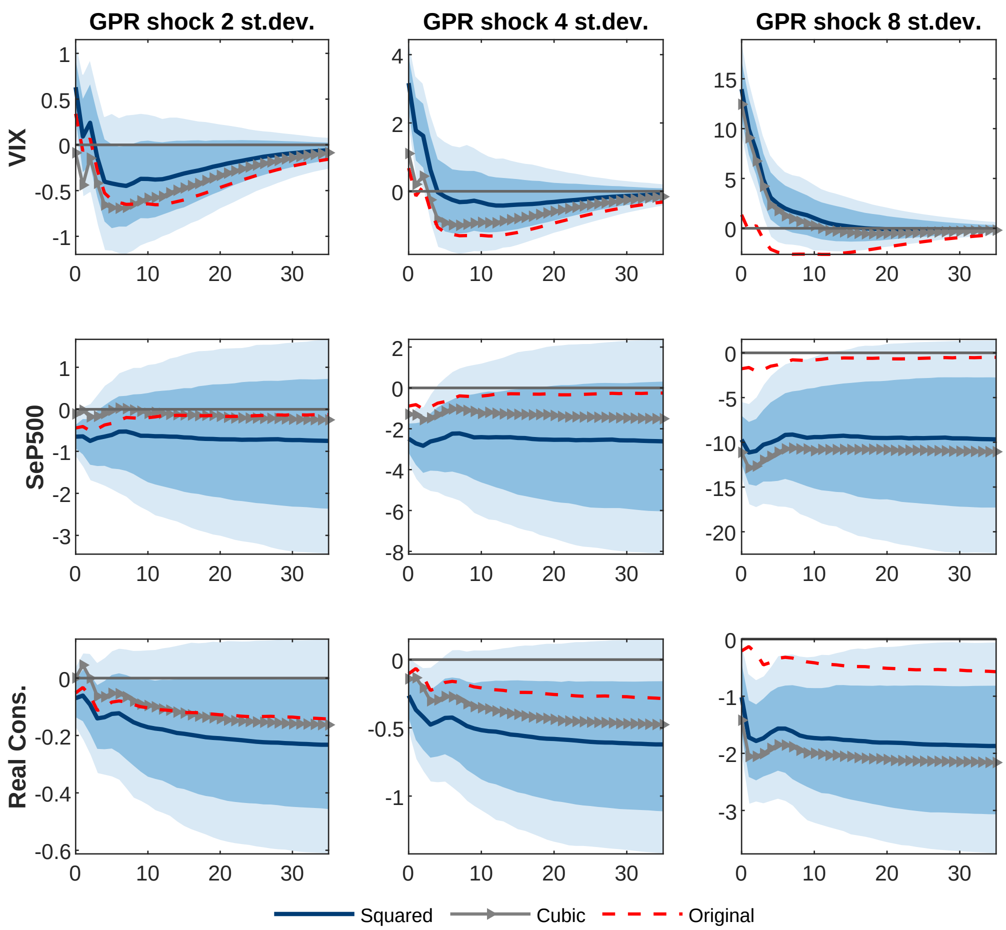
Notes: The solid blue line represents the median response to a GPR shock identified in the linear SVAR, while the shaded bands the 68% and 90% credible intervals. All variables in percent, except for the FED shadow rate in percentage points and the VIX in points.

Appendix Figure B3. Impulse Response Functions of the VARX using the linear and the non-linear GPR shock.



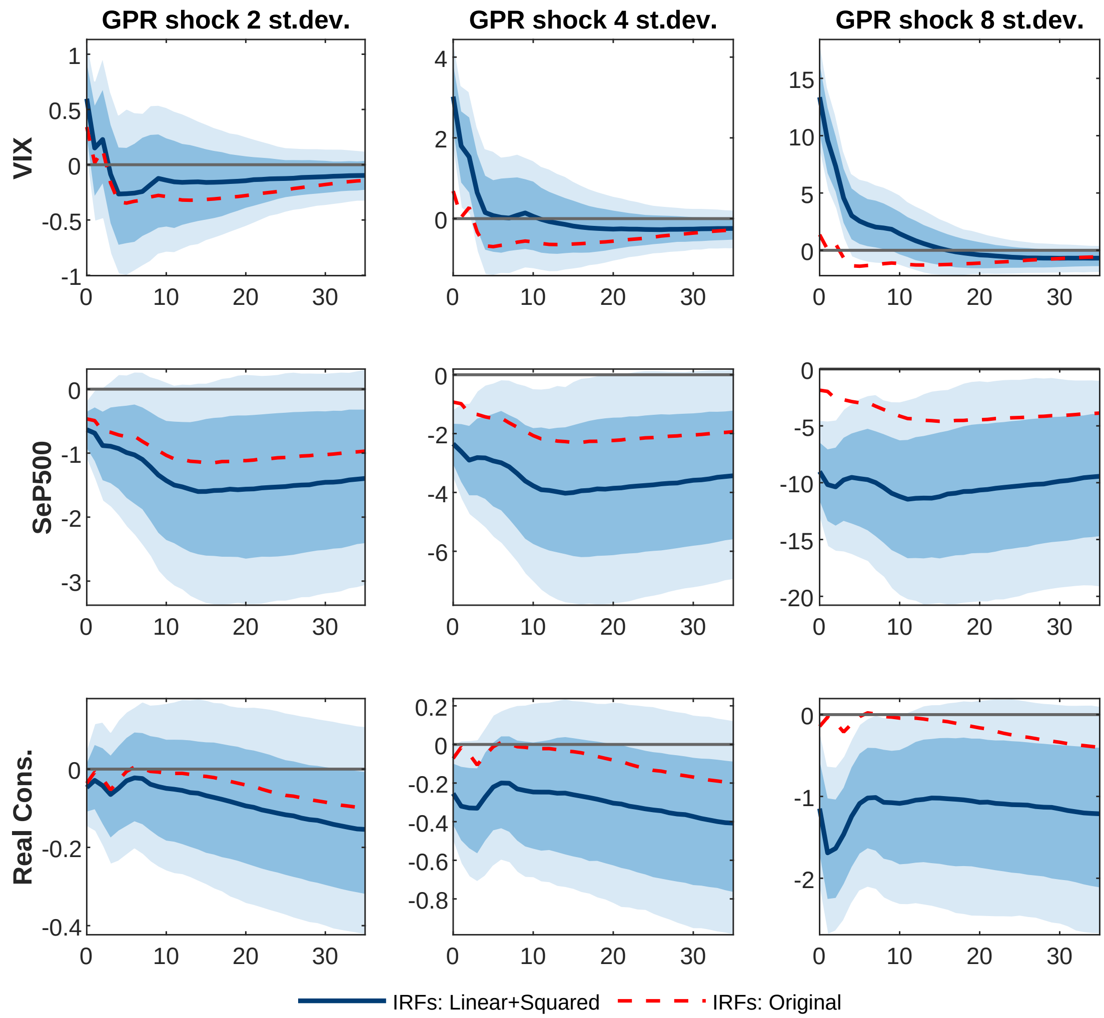
Notes: Baseline specification - all variables included in the model. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the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

Appendix Figure B4. Alternative non-linear specification of the shock



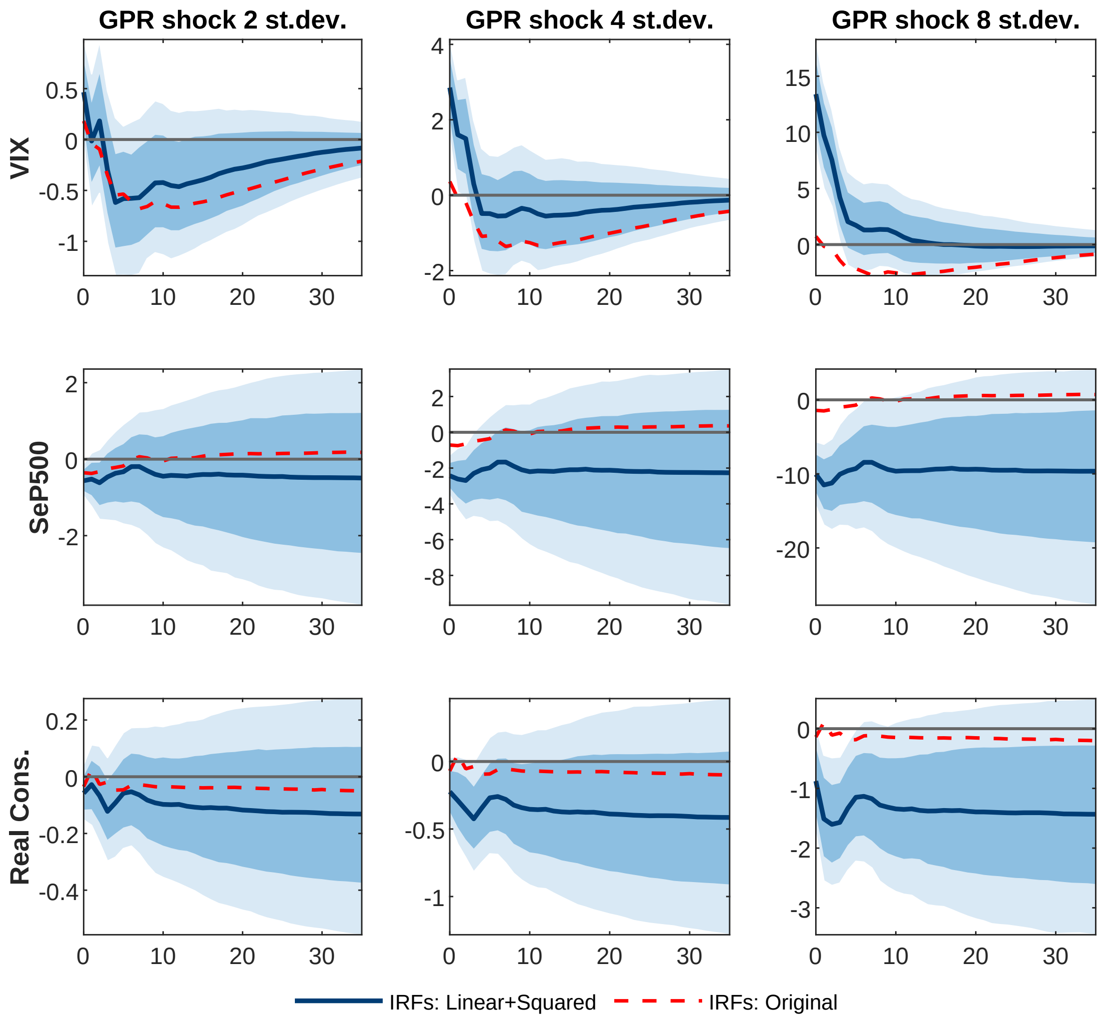
Notes: Results using using a cubic instead than a squared transformation of the non-linear component of the shock. The solid blue line represents the median response of the overall linear and non-linear (squared transformation) responses estimated in the second step, while the shaded bands the 68% and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

Appendix Figure B5. Robustness: Level Specification



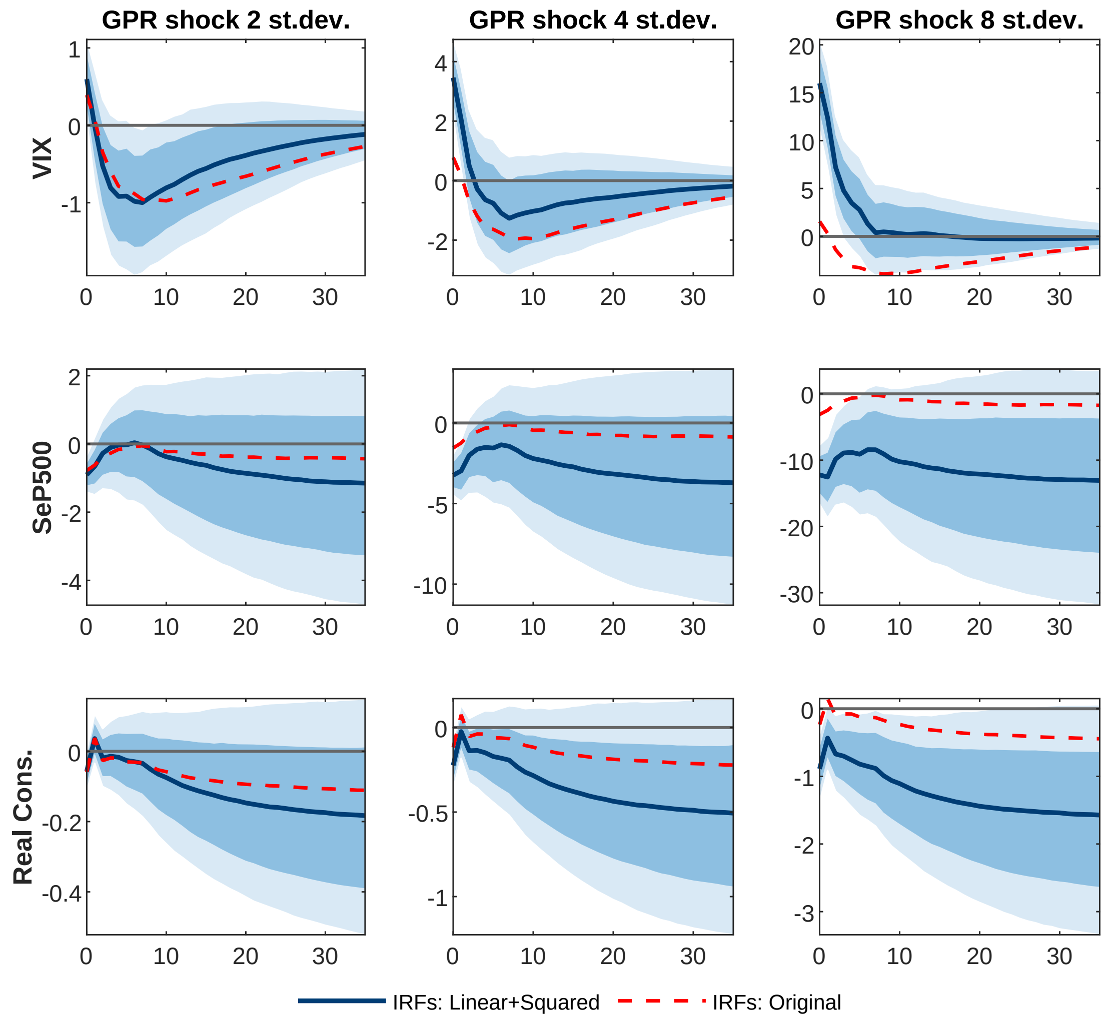
Notes: Specification considering the variables in levels. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first step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

Appendix Figure B6. 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 shows a different standard deviation of the shock.

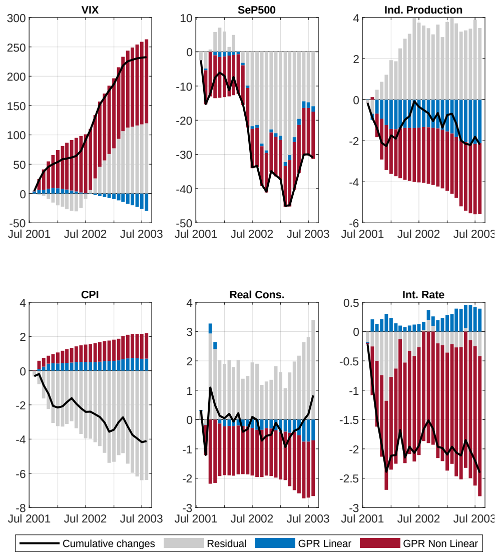
Appendix Figure B7. Robustness: Sample 1986-2019



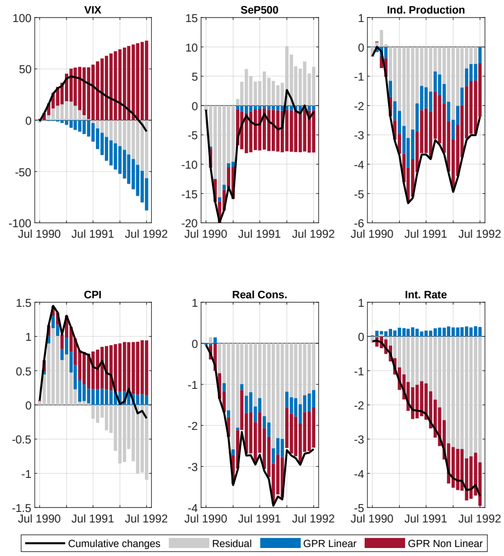
Notes: Selected results using the sample 1986M1-2019M12 as in Caldara and Iacoviello (2022). The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows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

Appendix Figure B8. Robustness: Single-unit prior and Historical Decomposition

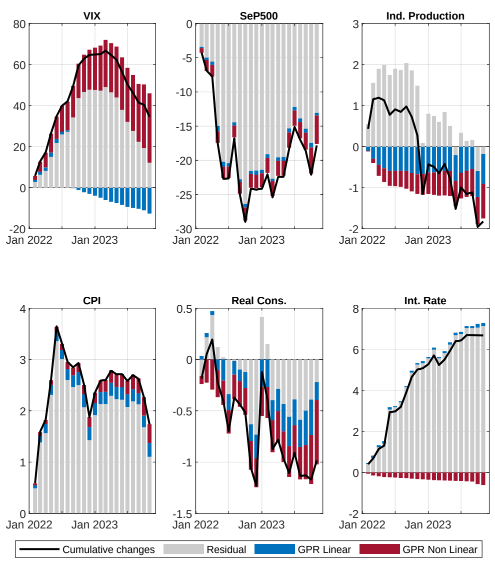
9/11 and Iraq War



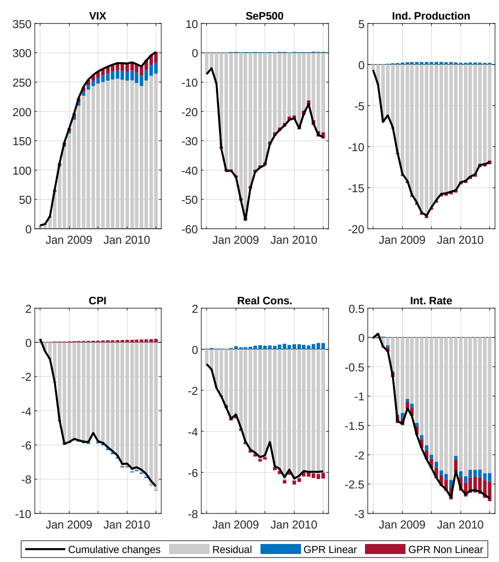
Gulf War



Russia's invasion of Ukraine



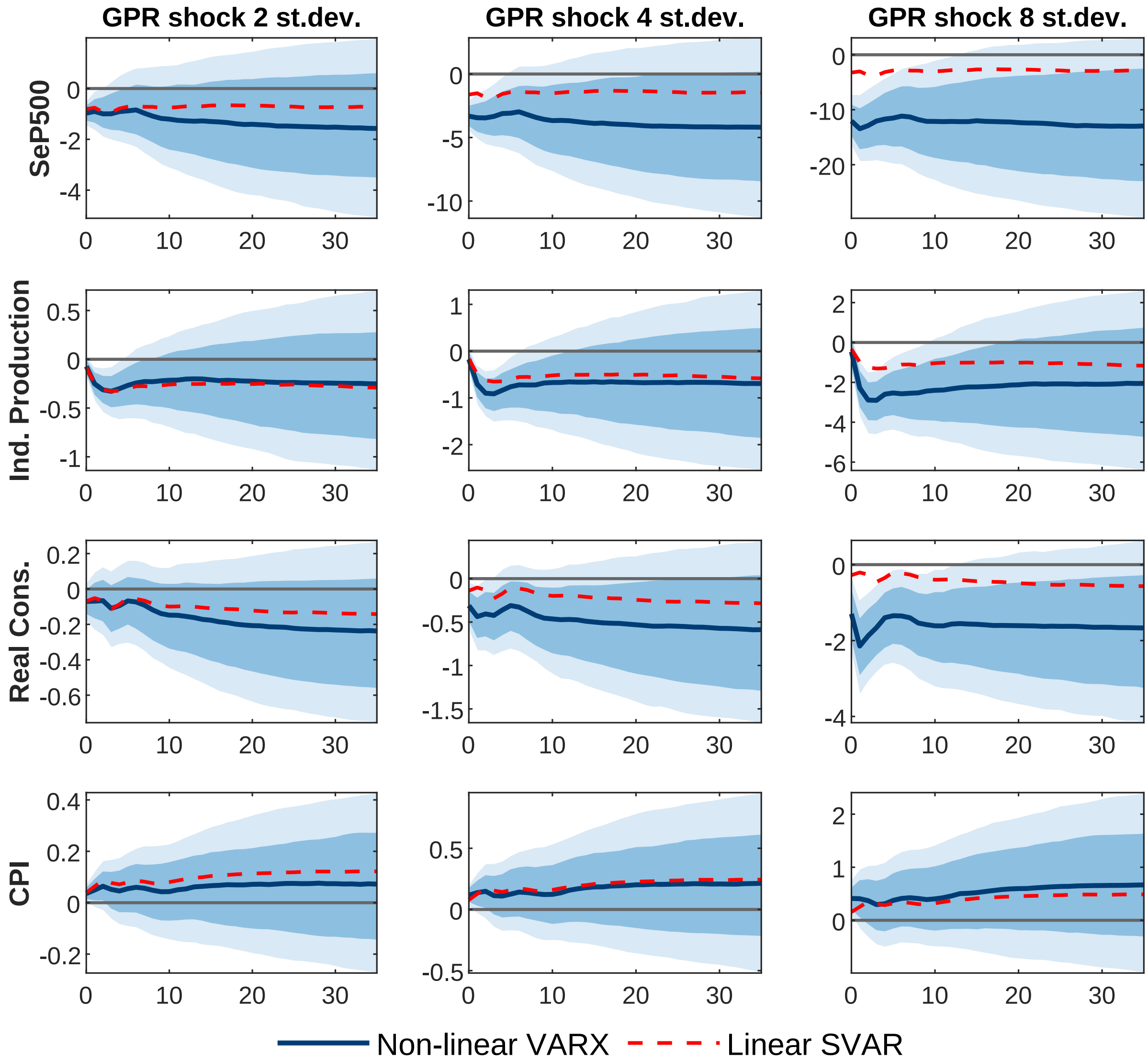
Great Financial Crisis



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 shows 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.

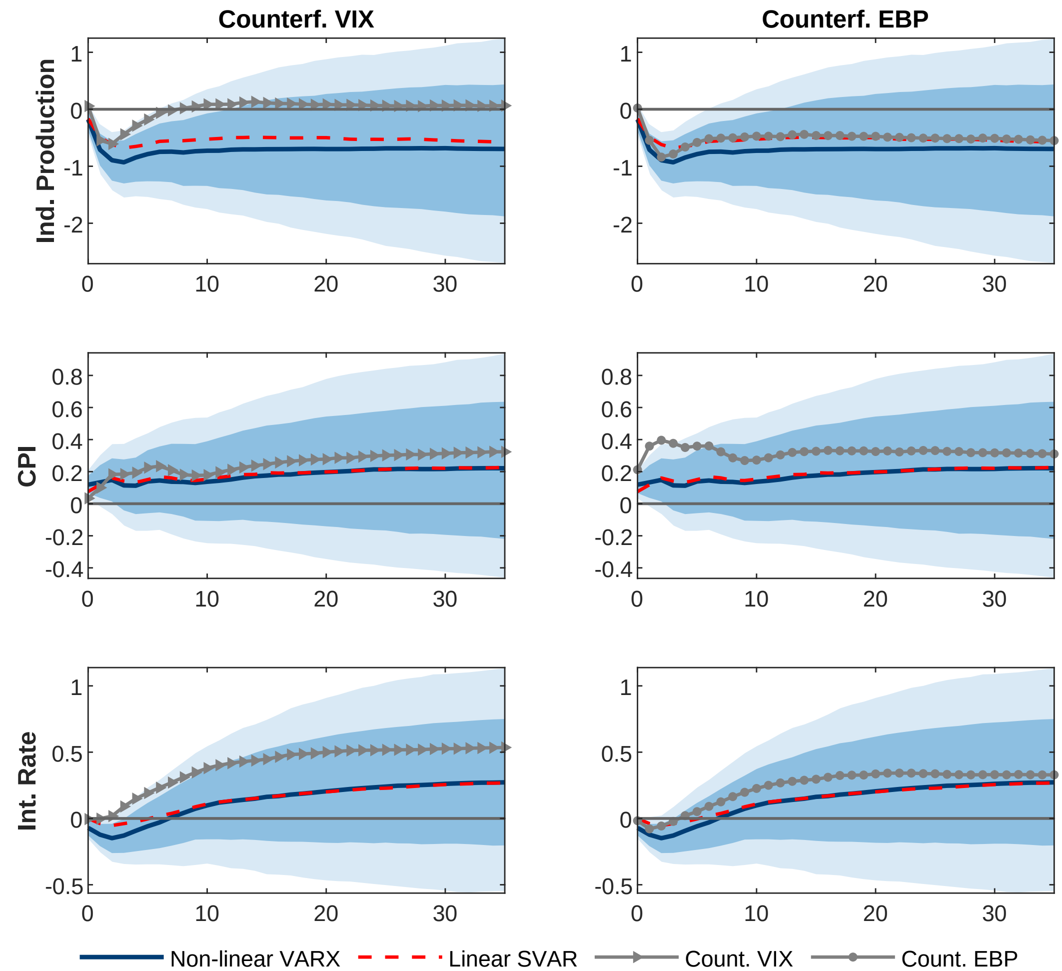
C Appendix: Additional Figures for Section 4: A Deep Dive in the Propagation Channels

Appendix Figure C1. Analysing other channels: Additional variables



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 shows 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.

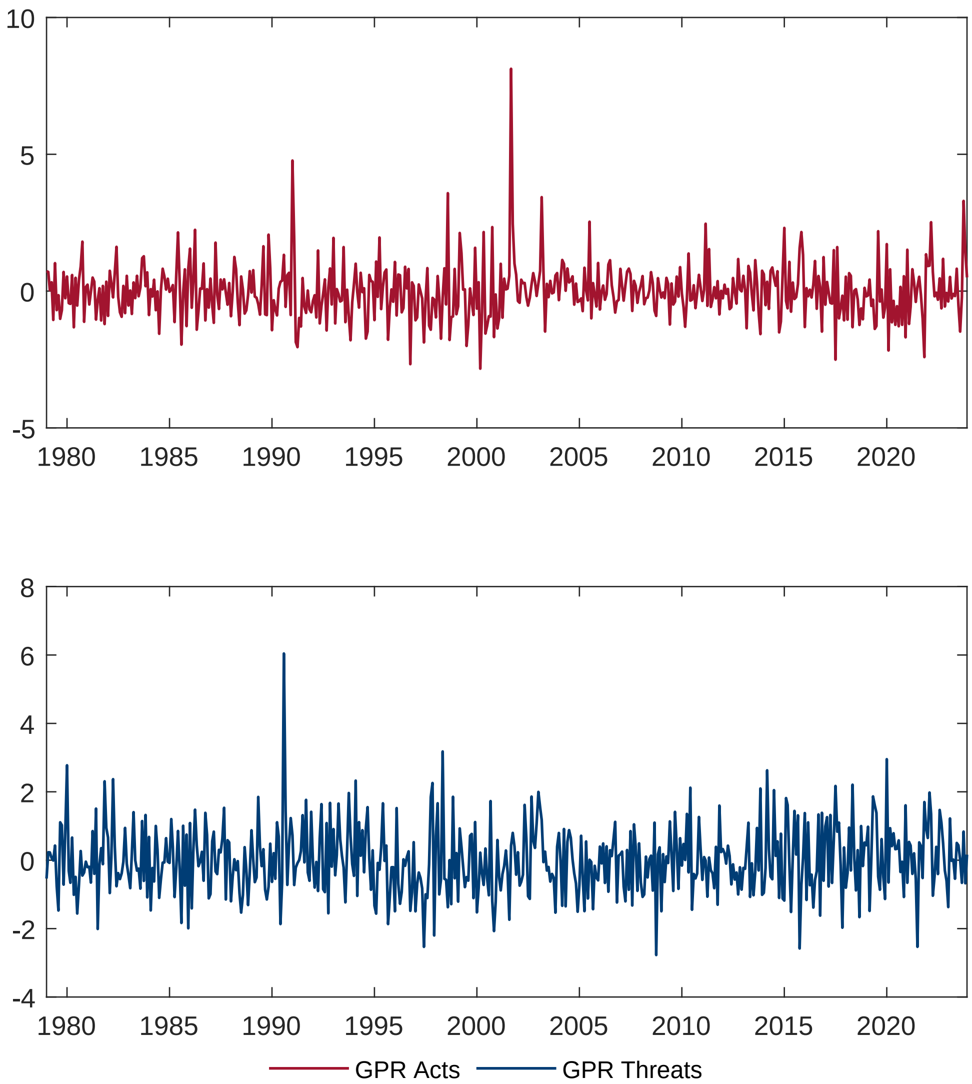
Appendix Figure C2. Counterfactual scenario: Additional variables



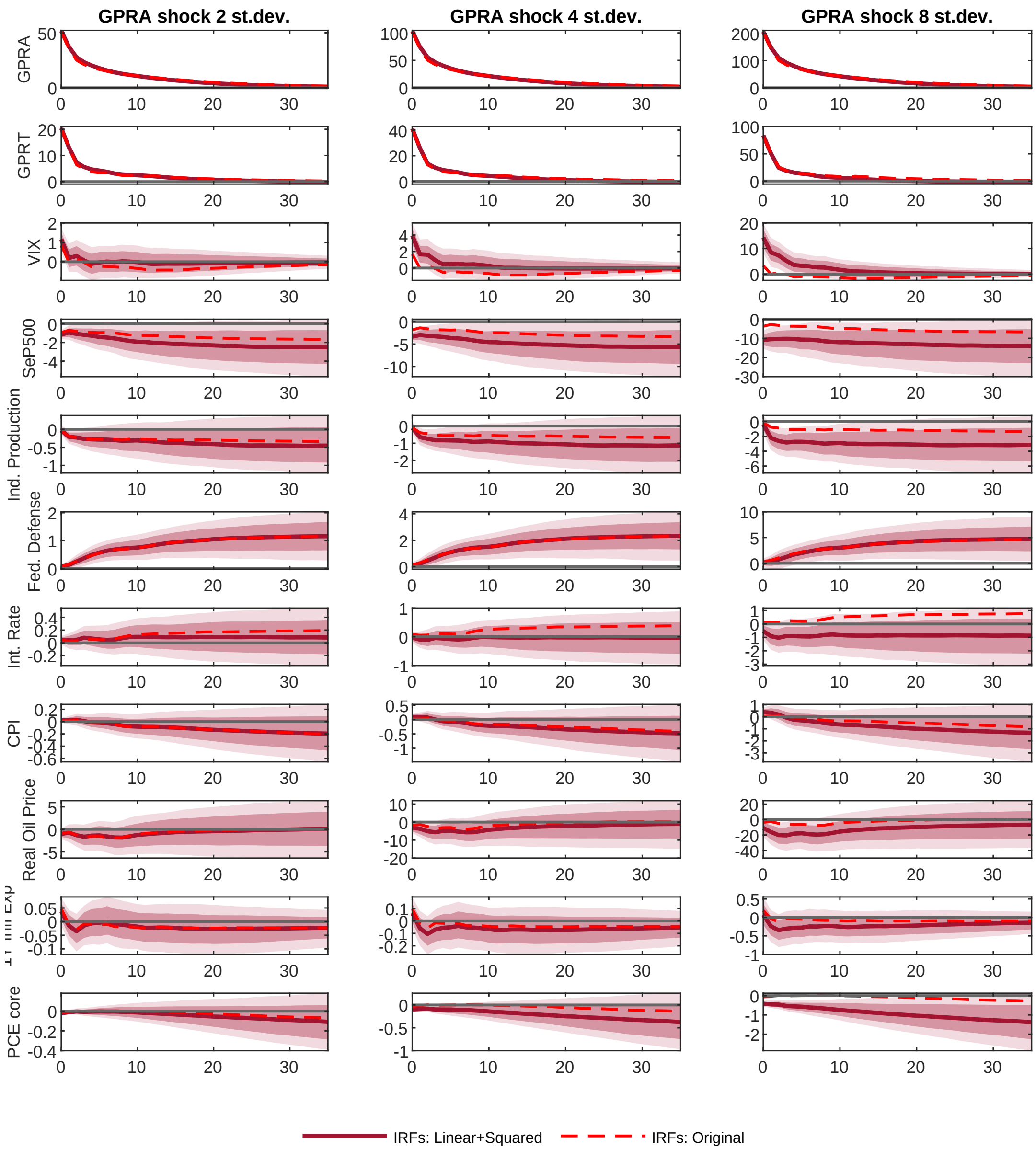
Notes: The left-hand side column shows results of the first counterfactual where the non-linear VIX response is switched off, while the right-hand side column shows results for the second counterfactual where the non-linear EBP shock is switched off. In both cases, responses coincide with a GPR shock equal to four standard deviations. The solid blue line represents the median response of the overall linear and non-linear dynamics estimated in the second step, while the shaded bands denote the 68% and 90% credible intervals. The dashed red line shows the responses from the first-step SVAR. The grey line shows the counterfactual impulse responses.

D Appendix: Additional Figures for Section 5 Unpacking Inflation Dynamics: The Role of GPR Threats and Acts

Appendix Figure D1. GPRA vs GPRT shocks

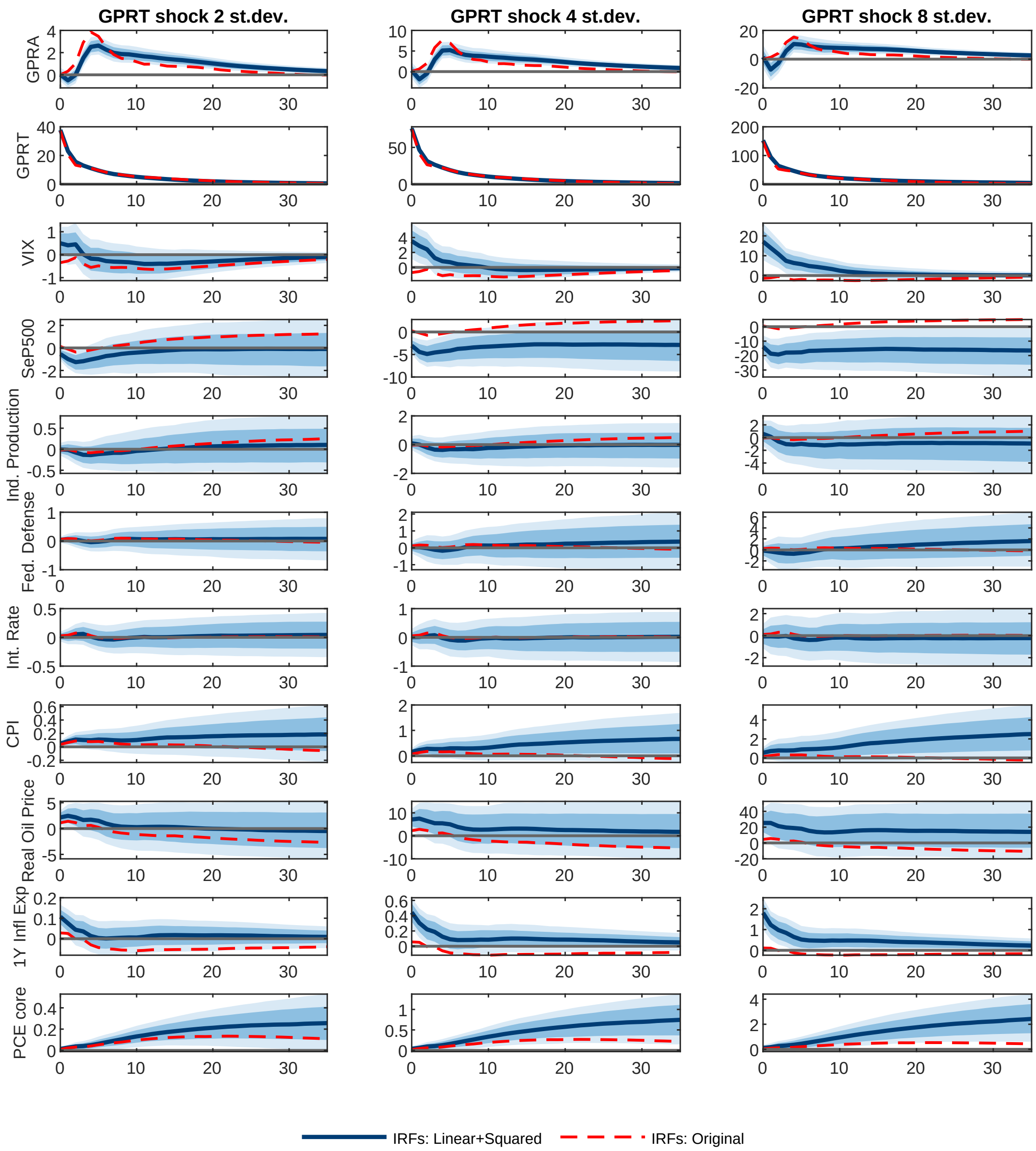


Appendix Figure D2. GPRA: IRFs of the VARX summing the linear and the non-linear responses to a GPRA shock



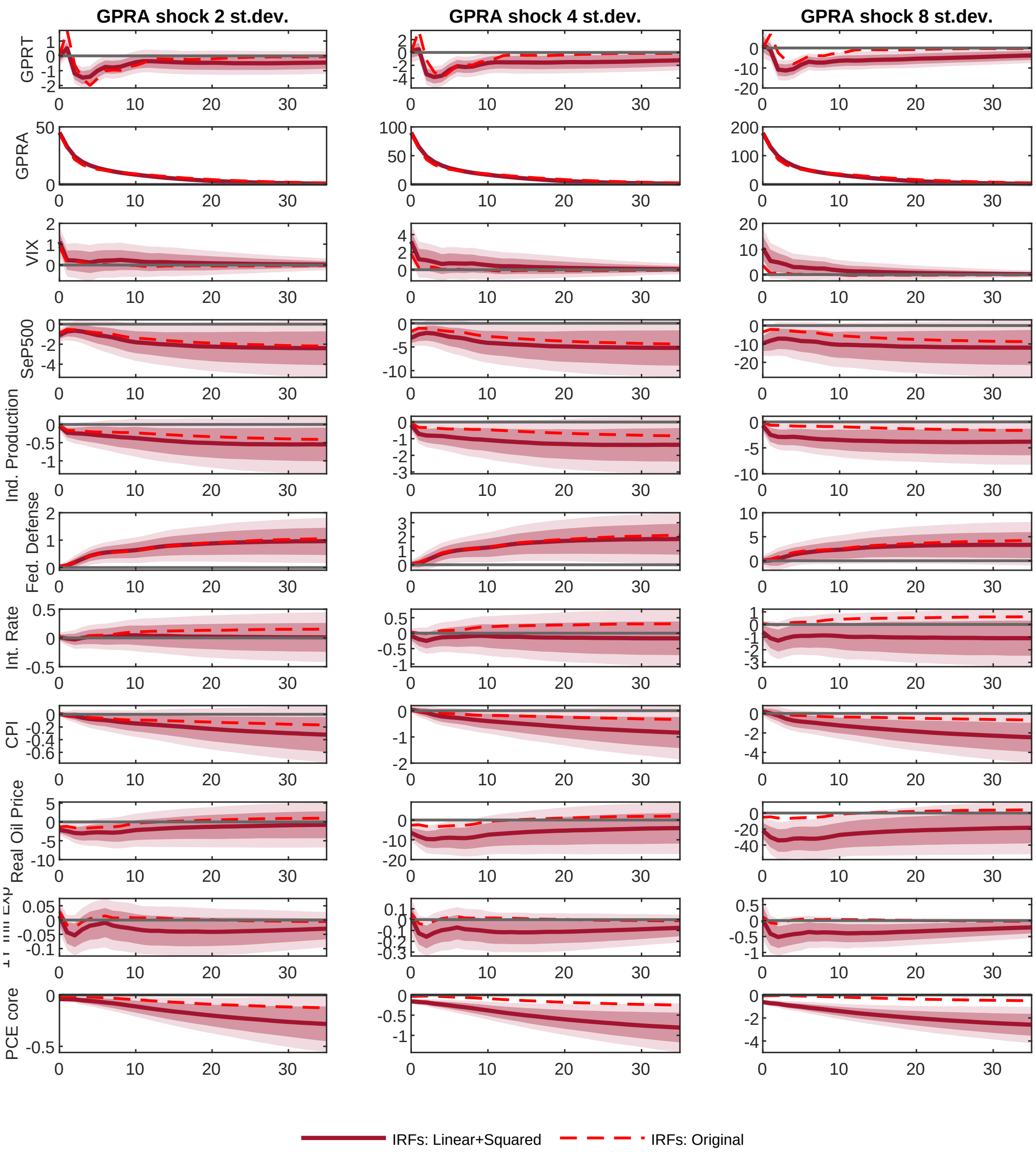
Notes: GPR Acts shocks - all variables included in the model. The solid red line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first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

Appendix Figure D3. GPRT: IRFs of the VARX summing the linear and the non-linear responses to a GPRT shock



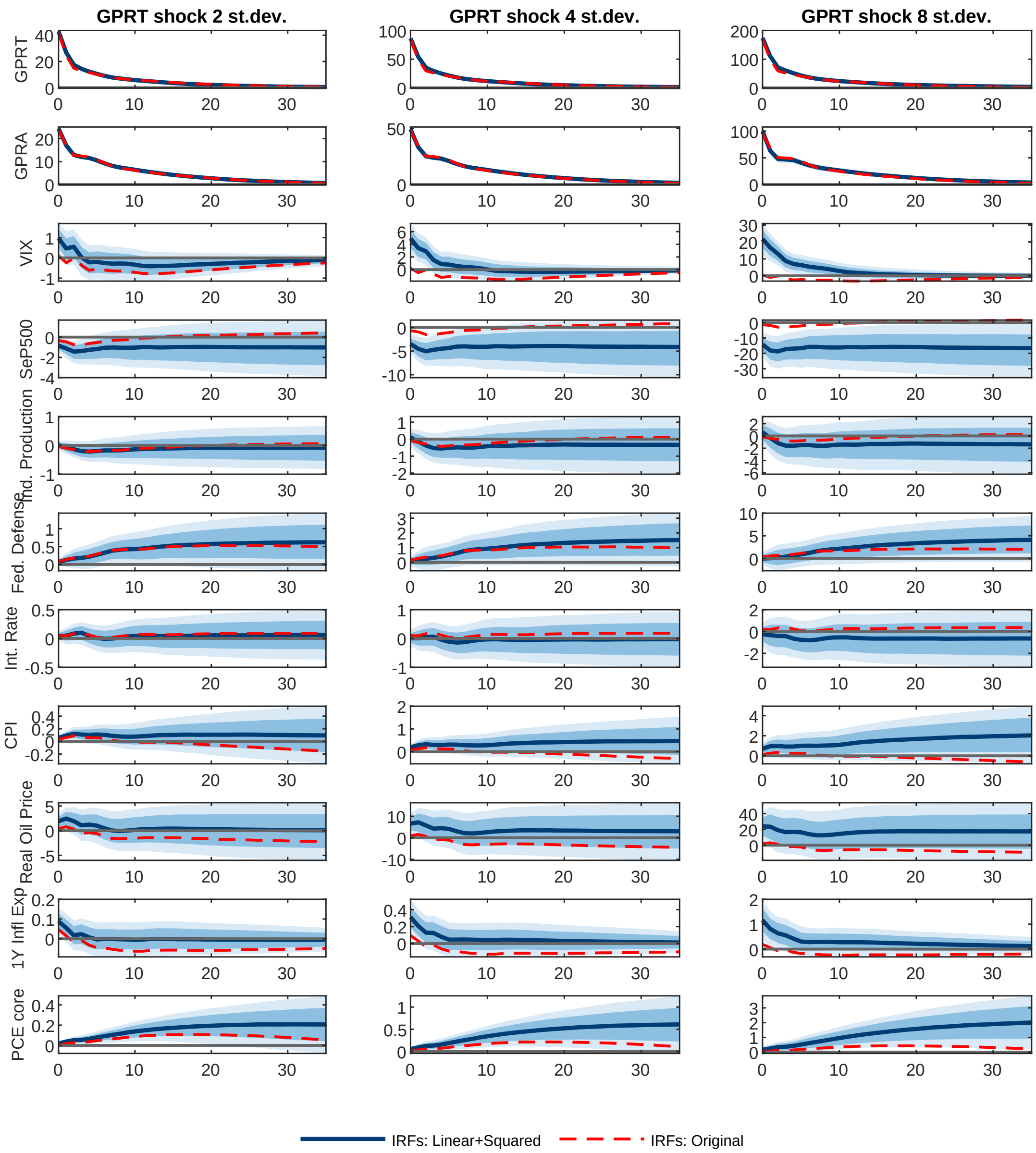
Notes: GPR Threats shocks - all variables included in the model. The solid blue line represents the median response of the overall linear and non-linear responses estimated in the second step, while the shaded bands the 68% and 90% credible intervals. The dashed red line shows the responses of the first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

Appendix Figure D4. 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 shows a different standard deviation of the shock.

Appendix Figure D5. 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 shows a different standard deviation of the shock.