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THE ASYMMETRY PUZZLE: THE SUPPLY CHAIN DISRUPTIONS NEWS SHOCKS EFFECTS ON OIL PRICES AND INFLATION

LAURENTIU GUINEA, LUIS A. PUCH y JESÚS RUIZ.

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The Asymmetry Puzzle: the Supply Chain Disruptions News Shocks effects on Oil Prices and Inflation*

Laurentiu Guinea,[a] Luis A. Puch[b] and Jesús Ruiz[b†]

[a]Universidad Carlos III de Madrid and ICAE
[b]Universidad Complutense de Madrid and ICAE

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PRELIMINARY VERSION

Abstract

This paper investigates the asymmetrical effects of supply chain disruptions on oil prices and inflation. To this purpose, we identify anticipated (news) shocks associated to the global supply chain. Then we estimate the effects of these shocks on oil prices and inflation in the US. We allow 'escalating' (restrictive) and 'deescalating' (expansionary) supply chain news shocks to have differing effect sizes. Our empirical findings reveal that anticipated supply chain disruptions exert a substantial and statistically significant influence on both oil prices and inflation. We uncover a significant asymmetry in these effects: 'escalating news' shocks exhibit a markedly stronger and more persistent impact compared to 'deescalating news' shocks. Consequently, the oil price is less sensitive to an alleviation of supply chain strain than to an exacerbation. Our results can be rationalized by a small open economy model which is used to assess the validity of our empirical approach. Furthermore, we demonstrate that the mechanisms governing the transmission of supply chain news shocks in the model align closely with observed empirical patterns. Failing to account for this asymmetry could lead to misjudgments regarding the repercussions of supply chain pressures.

JEL classification: E2, E6, E32, E44, Q42, Q43, Q58
Keywords: news shocks; inflation; oil prices; supply chain disruption; expectations;

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†Corresponding Author: Laurentiu Guinea, Department of Economics, Universidad Carlos III de Madrid, 28903 Madrid, Spain; E-mail: `lguinea@eco.uc3m.es`

1 Introduction

The global economy has experienced unprecedented disruptions within its supply chains in recent years, propelled by an array of factors ranging from natural calamities to the lingering repercussions of the COVID-19 pandemic, and more recently, escalating geopolitical tensions (Benigno et al., 2022). The dissemination of news regarding these disruptions unfolds over time and spans diverse economic and geographical dimensions, reverberating across industries and economies worldwide. This continuous accumulation of information exerts a substantial influence on inflation dynamics, as it shapes expectations and behaviors within the economic landscape. Amidst these disruptions, a substantial surge in oil prices has emerged, casting a profound influence on inflation trajectories, particularly in pivotal regions like the United States and Europe. However, what distinguishes these disruptions is their asymmetric impact as demonstrated by Tillmann (2024). News about increased supply chain disruptions is typically contractionary in nature, while news about decreased supply chain disruptions may be expansionary. These two types of news shocks do not uniformly impact oil prices and inflation dynamics, underscoring the need for a nuanced investigation. In this paper, we refer to contractionary news about supply chain disruptions as 'escalating news' and expansionary news about supply chain disruptions as 'deescalating news'.

The empirical research highlights a robust correlation between supply chain shocks and oil driven inflationary dynamics (Carrière-Swallow et al. (2023); Burriel et al. (2023); Ascari et al. (2024); Laumer and Schaffer (2023); Khalil and Weber (2022); Finck and Tillmann (2023); Liu and Nguyen (2023); Finck and Rudel (2023); Elsayed et al. (2023); De Santis and Stoevsky (2023)). In light of these findings, the global economy faces significant challenges due to supply chain disruptions. For example, supply chain disruptions exerted a significant influence compared to domestic aggregate demand shocks in accounting for Euro Area inflation during post-Covid-19 crisis as demonstrated by di Giovanni et al. (2022).[1] Recent geopolitical events, including tensions in the Middle East and the invasion of Ukraine, have further intensified these disruptions, resulting in notable price escalations in energy markets and essential food commodities such as wheat (Caldara et al., 2022).

However, despite the extensive body of work in this area, the impact of 'escalating' and 'deescalating' news shocks on supply chain disruptions and the asymmetric propagation mechanism towards oil prices and inflation remains largely unexplored. Those kind of news regarding supply chain dis-

[1] Figure A.1 in Appendix A shows the relationship between the supply chain disruptions and inflation for the US.

ruptions plays a pivotal role in shaping the expectations of consumers, businesses and governments, influencing their concerns regarding future economic growth and prospects for innovation and investment (Guinea et al. (2024); Guinea et al. (2023)). This heightened uncertainty often leads to reduced access to goods and services, which in turn contributes to increased commodities and oil prices and consequently inflation.

In this context, our study aims to investigate the asymmetric implications of supply chain disruption news shocks for oil prices and inflation dynamics, with a focus on the US. To achieve this goal, we employ a structural vector autoregression (VAR) model. Our contributions are twofold. Firstly, we identify news shocks associated with supply chain disruptions and categorize them into 'escalating news' - representing positive values of the identified news shock - and 'deescalating news' - representing negative values. Secondly, we estimate a VARX model (PESARAN and SMITH, 2006) that incorporates both 'escalating' and 'deescalating' identified news shocks as exogenous variables. We then demonstrate their effects on oil prices and inflation in the US. Additionally, we propose a dynamic general equilibrium model for a small open economy to assess the implications of supply chain disruption news shocks on oil prices and inflation. To the best of our knowledge, this paper is the first to identify news shocks associated with supply chain disruptions, categorize them into 'escalating news' and 'deescalating news,' and use them as exogenous variables in a VARX model.

Firstly, we use Barsky and Sims (2011) methodology to identify the news shocks captured in the global supply chain pressure index (Benigno et al., 2022).[2] The news shock is characterized by its lack of immediate impact on the variable of interest but its ability to predict future changes. The main mechanism involves the impact of news about supply chain disruptions on shaping expectations and uncertainty. This influence allows such news to anticipate future movements in oil prices, consequently affecting both current and future inflation dynamics.

Next, having identified the news shock, our focus shifts to investigating its asymmetric effects. To accomplish this, we utilize our earlier categorization of the news shocks into two distinct types: 'escalating' for positive values of the shock, indicating contractionary effects, and 'deescalating' for negative values of the shock, representing expansionary effects. This differentiation allows us to analyze the varying impacts of these shocks on the economy with greater precision. Then, drawing

[2]The global supply chain pressure index (Benigno et al., 2022), measures the common factor of several cross country and global indicators of supply chain pressures (e.g., delays in shipments and delivery times and shipping costs after purging these from demand measured by new orders), and it moves together with inflation both in the U.S. and in the Euro Area, where both started their ascent in post Covid-19 period.

on insights from Kilian and Murphy (2012), Baumeister and Hamilton (2019), and Kilian (2022), we proceed to implement a Bayesian VARX model PESARAN and SMITH (2006) to analyze these effects in greater detail.

Our VARX model encompasses oil prices, inflation, a conventional measure of economic activity based on industrial production (IPI), and the S&P500 index, alongside exogenous flows of 'escalating' and 'deescalating' news shocks. The outcomes of the resulting model estimates align closely with earlier findings concerning the relative significance of supply shocks in determining the price of oil, as indicated by structural vector autoregressive (VAR) models.[3] Our primary finding underscores that 'escalating news' supply chain disruption shocks exert a significantly stronger and more enduring effect compared to 'deescalating news' supply chain disruption shocks. Consequently, both oil prices and inflation demonstrate heightened sensitivity to the tightening of supply chain disruptions rather than their relaxation. Failing to consider this asymmetry may lead to a misinterpretation of the repercussions of supply chain pressure.

Given our empirical results, we aim to utilize a Dynamic Stochastic General Equilibrium (DSGE) model to clarify the transmission mechanisms of these disruptions, aligning our theoretical framework with observed empirical patterns. Our small open economy model builds on Castro et al. (2015), augmented with asymmetric news shocks, and integrates various essential elements, including wage and sectoral price rigidities, as well as real frictions such as habit persistence in consumption and adjustment costs in investment, exports, and imports.

The choice to utilize a small open economy model stems from our objective to capture the global segmentation evident in recent years, primarily attributed to the integration of the Chinese economy into international trade. This transformation has redefined the role of the US in the global trade landscape to a less prominent position. Despite its relative size within the supply chain network, the US remains profoundly susceptible to supply chain disruptions, as much as smaller countries. This emphasizes the urgent need to comprehend the ramifications of accumulating news shocks within these chains, whether originating from trade tensions, geopolitical turmoil or natural calamities. By adopting a small open economy model, we can examine the intricate ways in which such disruptions reverberate throughout the economy, particularly impacting oil prices and inflation dynamics.

[3] Over the past decade, structural VAR models have become a common tool for comprehending the dynamics of oil prices. Baumeister and Hamilton (2019) emphasize the significance of oil supply and demand shocks in driving real oil price changes, warranting their inclusion in structural VAR models. Kilian and Murphy (2014) Kilian and Murphy (2012) and Kilian (2022) further contributes to this understanding.

Methodologically, our model combines two strands of the DSGE literature. Firstly, draws upon insights from various sources, including Adolfson et al. (2007) Adolfson et al. (2008), Christiano et al. (2005), Christoffel et al. (2008), Medina and Soto (2007), Dorich et al. (2013), Smets and Wouters (2003) and Smets and Wouters (2007). Second, our paper relates to the news shocks literature as it encompasses two additional components: (i) news shocks pertaining to the external channel for imports, which magnifies the effects of changes in external conditions on the economy, serving as a set of supply chain frictions, and (ii) asymmetric news shocks on imported goods utilized in the production function of differentiated goods. Thus, our model contributes to the literature on news shocks by incorporating these dynamics.[4]

In our analysis, we illustrate that the mechanisms driving the transmission of supply chain news shocks in the model closely mirror empirical observations. We show how these news shocks propagate through various channels, affecting different sectors and economic agents in a manner consistent with what is observed in the data. By closely aligning our model's dynamics with empirical patterns, we enhance our understanding of how supply chain disruptions impact the broader economy and inform more effective policy responses.

In summary, our study contributes to the existing literature with a thorough examination of the asymmetric supply chain disruptions effects and their repercussions on oil prices and inflation dynamics, particularly focusing on the US. By untangling the complex connections among supply chain shocks, oil prices, and inflation, we aim to furnish policymakers and stakeholders with valuable insights for navigating the complexities of the global economy. This underscores the imperative of understanding these asymmetrical effects when formulating effective policy responses, given the complex interplay between supply chain disruptions and the subsequent surge in oil prices. It highlights the pressing necessity of comprehending how news shocks regarding these disruptions disseminate throughout the economy.

The rest of the paper is organized as follows. Section 2 describes the data and Section 3 presents the methodology. Section 4 presents the empirical results. Section 5 presents the theoretical model and its results. Finally, Section 6 concludes and discusses the implications of the findings.

[4] A growing literature assigns a central role in accounting for the bulk of business cycles to news shocks (or shocks to future fundamentals), which affect people's economic behavior such as consumption, hours, and investment by changing people's expectations about the future. (Beaudry and Portier (2006) Ben Zeev and Khan (2015); Beaudry and Portier (2014); Ben Zeev et al. (2020); Görtz et al. (2022) Guinea et al. (2023).

2 Data

We use monthly data from February 2012 to December 2023. The initial period is marked by the emergence of supply chain disruptions, signifying their increasing visibility. We exclude the period before 2012, as it coincided with the recovery phase from the Great Recession, during which international trade operated smoothly. The concluding period encompasses the onset of significant inflationary pressures, commonly known as the "Big Inflation", accompanied by heightened geopolitical turmoil, including the tensions in the Middle East and the war in Ukraine, and a notable surge in oil prices. All data are publicly available from the Federal Reserve Economic Data (FRED) and the Bureau of Economic Analysis. The details regarding our series are provided in Section A.

3 Methodology

Our empirical methodology combines Barsky and Sims (2011) news shock identification with modeling using VARX (PESARAN and SMITH, 2006). This approach enables us to capture the nuanced effects of supply chain disruptions on oil prices and inflation dynamics, shedding light on the asymmetric nature of these shocks and their implications for the broader economy.

To identify the news shock related to supply chain disruptions we use Barsky and Sims (2011) methodology as described in Appendix B. This methodology captures the anticipated shocks in the global supply chain pressure index (Benigno et al., 2022).[5] Once the news shock on supply chain disruptions is identified, following Tillmann (2024), we decompose it into two categories: "escalating news" by selecting the positive values and "deescalating news" by selecting the negative values as follows: $\varepsilon_t^{news+} = \max\left[0, \varepsilon_t^{news}\right]$ and $\varepsilon_t^{news-} = \min\left[\varepsilon_t^{news}, 0\right]$, where 'escalating news', ε_t^{news+}, represent periods of heightened concern or restrictive developments in supply chains, while 'deescalating news' , ε_t^{news-}, indicate improvements or expansionary developments. This decomposition allows us to capture the asymmetric effects of supply chain shocks on economic variables such as oil prices and inflation.

Subsequently, we introduce the decomposed shock into 'escalating news' and 'deescalating news' as exogenous variables within a Vector Autoregressive with Exogenous Variables (VARX) model

[5] The global supply chain pressure index (Benigno et al., 2022), measures the common factor of several cross country and global indicators of supply chain pressures like delays in shipments and delivery times and shipping costs after purging these from demand measured by new orders.

PESARAN and SMITH (2006). The VARX model allows us to analyze the dynamic relationships between the identified news shocks, oil prices, and inflation. We estimate the impact of the decomposed news shocks on oil prices and inflation trajectories, considering both short-term and long-term effects. Additionally, we assess the transmission channels through which news shocks propagate to economic variables, providing insights into the mechanisms driving the effects of supply chain disruptions on oil prices and inflation. This model includes key economic indicators beside oil prices and inflation rates. By fitting the 'escalating' and 'deescalating' news shocks alongside these variables, we aim to examine their exogenous effects on oil prices and inflation dynamics.

3.1 Identification of Supply Chain Disruption News Shocks

To identify supply chain disruption news shocks, we scrutinize key market drivers that exert significant influence over global supply chains. Specifically, we closely examine various components related to oil, essential for powering transportation and industrial processes, as well as technology utilized in communication and transportation sectors. Furthermore, we analyze commodities and food indices, which are crucial for various industries and consumer goods. Additionally, we take into account raw materials and components that are especially vulnerable to supply chain disruptions, as they can significantly affect the overall stability and functionality of the global supply chain. Moreover, we incorporate controls for the effects of climate change, trade disruptions, and the global economy.[6]

The Structural Vector Autoregression (SVAR) model used to identify the news shock includes eight economic indicators: Global Supply Chain Pressure Index (GSCPI) (Benigno et al., 2022), GECOM (Baumeister et al., 2022), the Global Uncertainty Index (GUI) (Baker et al., 2016), Trade Policy Uncertainty (TPU) (Caldara et al., 2020), Climate Uncertainty Index (CLU) (Gavriilidis, 2021), BHP commodities Index, Reli petro oil Index, and ITC food Index.

Barsky and Sims (2011) propose a method for identifying news shocks in a Structural Vector Autoregression (SVAR), which is suitable for estimating either an unrestricted VAR or a Vector Error Correction Model (VECM) with cointegration relations.[7] In this approach, the Global Supply Chain Price Index (GSCPI) serves as the key variable of interest used to identify news shocks. It occupies the first position in the SVAR model alongside other variables linked to supply chain

[6]We chose these indexes from various sources that specifically focus on companies involved in the global supply chain. Our selection was guided by the clarity and specificity of these indexes in capturing disruptions within the global supply chain, enabling a more precise evaluation of the impact of news shocks on economic variables.

[7]This section presents a concise summary of the methodology, with further details provided in Appendix B

disruptions. The news shock is identified as the shock that most accurately predicts the future movements in GSCPI, beyond what can be explained by its own innovation. Following the maximum forecast error variance (FEV) identification approach proposed by Barsky and Sims (2011) , we assess the responses to the identified shock over a thirty-six-month period to ascertain whether they deviate significantly from zero (see Appendix B for detailed information). We estimate a Bayesian VAR system in (log-)levels.[8] The Akaike criteria, the Hannan-Quinn information and Schwarz criteria prescribe between ten and twelve lags. As a benchmark, we choose to estimate a VAR with twelve lags. The results are robust to using a different number of lags, and any order of the variables in the VAR. We test for each realization (3000) the existence of unit roots and for the residuals to be white noise.[9]

This methodology of identifying news shocks offers flexibility by permitting, but not requiring, a permanent impact on the variable of interest from the news shock. Additionally, it imposes no constraints on common trends among the various variables in the VAR model. Furthermore, as a partial identification method, this approach can be applied to VARs with multiple variables without requiring additional assumptions about other shocks.

3.2 The Global Supply Chain Disruption News Shocks

Following Tillmann (2024), we decompose the identified news shock on the global supply chain disruptions into 'escalating' and 'deescalating' values as follows: $\varepsilon_t^{news+} = \max\left[0, \varepsilon_t^{news}\right]$ and $\varepsilon_t^{news-} = \min\left[\varepsilon_t^{news}, 0\right]$. The 'escalating news', ε_t^{news+}, represent periods of heightened concern or restrictive developments in supply chains, while 'deescalating news ', ε_t^{news-} indicate improvements or easing supply chain restrictions. Figure 1 represents this decomposition.

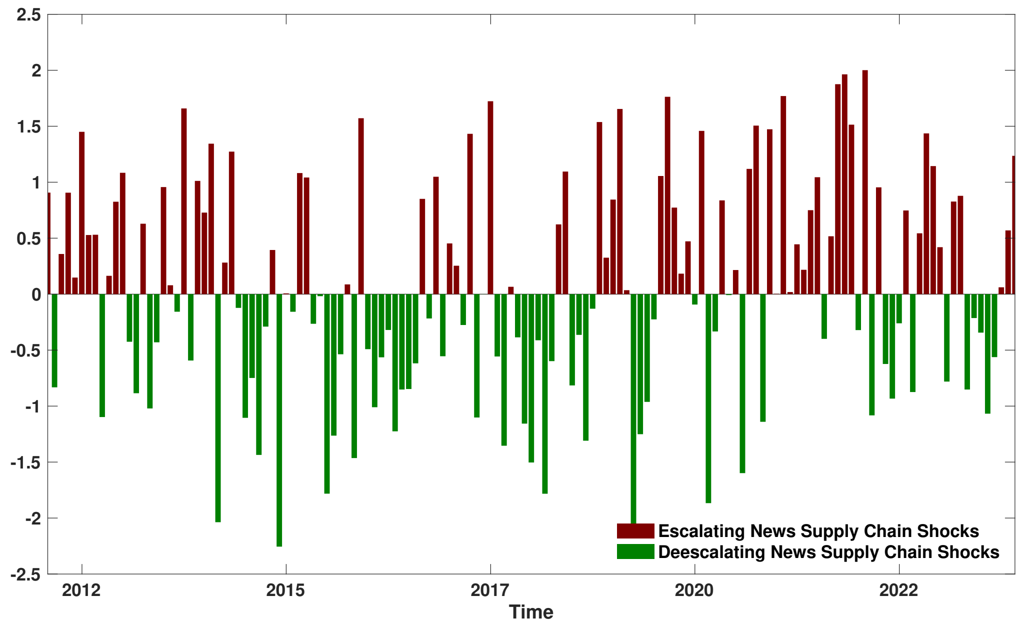
3.3 VAR model with news shocks as exogenous variables

In VARX models, exogenous variables, denoted as Z_t are additional factors that are believed to affect the endogenous variables but are not affected by them. In our model Z_t are the $[\varepsilon_t^{news+}, \varepsilon_t^{news-}]$. These variables are included in the model to capture their influence on the system dynamics. The

[8] We use the MATLAB main program routine provided by Kurmann and Otrok (2013).

[9] Appendix C presents the autocorrelation and partial autocorrelation function of the estimated SVAR residuals.

Figure 1: **The news shocks decomposition into 'escalating' and 'deescalating' shocks**



Notes: The series shows the 'escalating' and 'deescalating' news supply chain disruption shocks. It is the residual from identified news shocks on the Global Supply Chain Pressure Index (GSCPI).

VARX model is specified as:

$$Y_t = \mu + \sum_{j=0}^{q} C_j Z_t + \sum_{j=1}^{p} A_j Y_{t-j} + U_t. \tag{3.1}$$

The $Y_t \in R^k$ is a vector $(ny \times 1)$, μ is a vector of intercepts $(ny \times 1)$, C_j are coefficient matrices $(ny \times nx)$, $Z_t \in R^m$ is a vector $(nx \times 1)$, A_j are coefficient matrices $(ny \times ny)$, $Y_{t-j} \in R^k$ is a vector $(ny \times 1)$, and u_t is the vector of errors $(ny \times 1)$. The crucial condition for the correctness of this model is that

$$E\Big[U_t | \{Y_{t-j}\}_{j=1}^{\infty}, \{Z_{t-i}\}_{i=1}^{\infty}\Big] = 0 \ (\in R^m). \tag{3.2}$$

with probability 1. Next, assuming a VAR model for Z_t itself

$$Z_t = c_0 + \sum_{j=1}^{r} D_j Z_{t-j} + V_t. \tag{3.3}$$

$$E\Big[V_t | \{Y_{t-j}\}_{j=1}^{\infty}, \{Z_{t-i}\}_{i=1}^{\infty}\Big] = 0 \ (\in R^m). \tag{3.4}$$

Note that model 3.3 implies that Y_t does not Granger-cause Z_t which is a weak form of exogeneity.

Using bayesian estimation with a diffuse prior, we can estimate the model written in matricial form:

$$\mathbf{Y} = \mathbf{X}\mathbf{B} + \mathbf{U}. \tag{3.5}$$

where the dimension of $\mathbf{Y}$ is $(T \times ny)$, $\mathbf{X}$ is $(T \times (1 + nx(q+1) + ny * p) \times ny)$, $\mathbf{B}$ is the matrix of coefficients $(1 + nx(q+1) + ny * p) \times ny)$ and $\mathbf{U}$ is the matrix of errors $(T \times ny)$.

4 Empirical results

The impulse response functions derived from the VARX model as shown in Fig 2 unveil significant dynamics regarding oil prices in response to supply chain disruption news shocks. Specifically, oil prices exhibit a stronger and more persistent positive response to a 'escalating news' supply chain shock compared to a 'deescalating news' shock. This asymmetrical behavior is characterized by a higher amplitude and persistent effects, highlighting the substantial impact of 'escalating news' shocks on oil price dynamics.

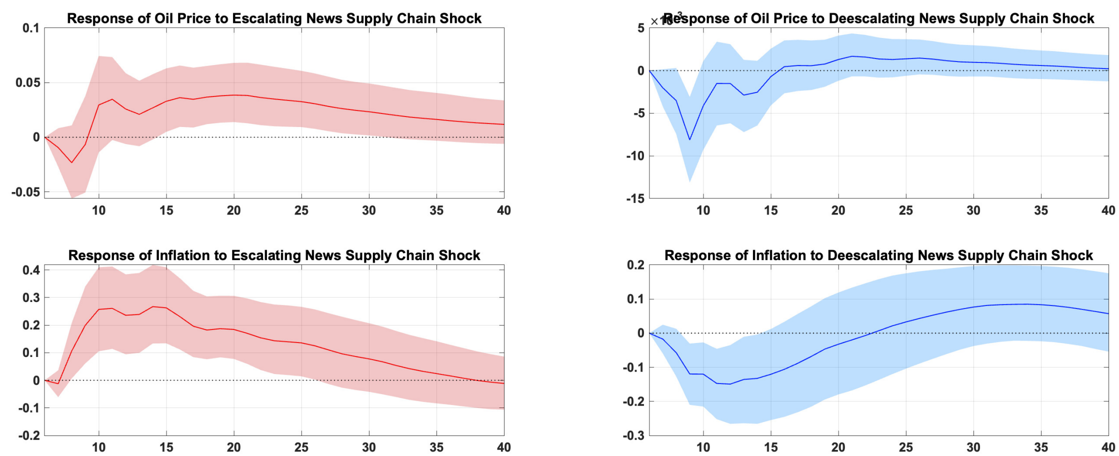
Similarly, we observe a parallel pattern in the response of inflation to supply chain disruption news shocks. Like oil prices, inflation demonstrates a more pronounced and enduring positive response to 'escalating news' shocks compared to 'deescalating' ones. This consistent asymmetrical behavior underscores the influential role of 'escalating news' shocks in shaping inflation dynamics, with their effects persisting over an extended period.

Intuitively, we interpret that 'escalating news' about disruptions may signal larger-scale problems in the supply chain that accumulate over time, causing greater uncertainty and resulting in more substantial adjustments in prices and economic behavior. Conversely, 'deescalating news' may indicate temporary or localized disruptions, leading to less significant adjustments in the economy.

The inflation's heightened response can be attributed to various factors beyond supply chain disruptions. While supply chain disruptions directly impact not only energy prices but also raw material and food prices, their effects extend beyond this sector. Firstly, there's a substitution effect that can be applied to food, raw materials or energy resources. For example, consumers and firms pivot towards alternative energy sources like gas or renewables due to escalating oil prices, or to raw materials not directly affected by supply chain disruptions. This shift in consumption patterns can ripple through the economy, influencing price dynamics across different sectors.

Moreover, the increased costs of production inputs resulting from supply chain disruptions, particularly in energy-related sectors, can trigger price hikes across various industries. These disruptions affect the production process, leading to higher costs, which are eventually passed on to consumers in the form of elevated prices. As a result, the inflationary pressures stemming from these disruptions permeate throughout the economy, contributing to the overall uptick in inflation.

Figure 2: **IRF: Oil price and inflation response from the VARX estimation**



Notes: The impulse response functions from the VARX estimation. The red and blue area represent the 68% confidence interval.

In concluding this section, we summarize our interpretations, emphasizing the divergent pathways through which 'escalating' and 'deescalating' news shocks manifest in the economy. We elucidate how 'escalating news' shocks tend to exert stronger and more enduring effects compared to their 'deescalating news' counterparts, shaping the trajectory of economic variables in distinct ways. Through this analysis, we illuminate the nuanced interplay between supply chain disruptions and key economic indicators, contributing to a deeper comprehension of the complexities inherent in the asymmetric transmission of news shocks.

5 The theoretical model

To interpret the empirical findings, we incorporate news shocks into the small open economy model proposed by Castro et al. (2015). The choice to employ a small open economy model is justified by multiple factors. Firstly, the US economy heavily relies on international trade, with substantial imports and exports of commodities, goods, and services. This dependency underscores the need for a modeling approach that accurately captures its exposure to global markets. A small open economy model precisely provides this capability by explicitly incorporating trade flows, exchange rate dynamics, and the influence of worldwide economic conditions on domestic variables. Given its interconnectedness with the global economy, the US is vulnerable to external shocks, including fluctuations in global commodity prices, shifts in foreign demand, and currency exchange rate movements. By employing a small open economy model, we can effectively examine how these external shocks propagate to domestic variables, providing valuable insights into their impact on the economy.

Additionally, this choice also reflects our objective to address the global segmentation evident in recent years, primarily attributed to the integration of the Chinese economy into international trade. Despite its relative size within the supply chain network, the US remains profoundly susceptible to supply chain disruptions, similar to smaller countries. This underscores the urgent need to comprehend the ramifications of accumulating news shocks within these chains, whether originating from trade tensions or natural calamities. By adopting a small open economy model, we can investigate the intricate ways in which such disruptions reverberate throughout the economy, particularly impacting oil prices and inflation dynamics.

In the model proposed by Castro et al. (2015), there are multiple types of agents: households, domestic producers, importing firms, and the government. Among households, two distinct types exist. Both share the same endowment of time, which they allocate between labor and leisure. However, they vary in their engagement with capital, asset, and labor markets. Efficient households possess ownership of the capital stock and all shares of firms, enabling them to accumulate financial assets. Conversely, rule-of-thumb households face financial constraints, lacking access to financial markets and relying solely on their labor income for consumption.

Within the domestic production landscape, three distinct groups of producers play pivotal roles: domestic input producers, intermediate good producers, and final good assemblers. Intermediate good producers, in particular, are further segmented into four sectors based on the final product supplied: private consumption goods, government consumption goods, investment goods, and exported goods. The production process unfolds across three stages, each marked by specific activities and economic agents.

In the first stage, representative firms engage in the production of non-tradable domestic inputs, leveraging capital and labor resources. Concurrently, importing firms source a diverse array of differentiated goods from international markets, which are then passed on to assemblers. These assemblers undertake the task of transforming the imported goods into homogeneous inputs, primed for integration into the production process. Moving to the second stage, a multitude of intermediate good producers step in, blending both domestic and imported inputs to craft a spectrum of differentiated varieties. The ratio of domestic to imported inputs varies across sectors, reflecting the distinct demands and production dynamics of each segment. Finally, in the third and ultimate stage, sectoral assemblers take center stage once again. Here, they orchestrate the harmonious fusion of the intermediate varieties, culminating in the creation of homogeneous goods. These goods, now refined and standardized, find distribution both within domestic markets and on the international stage.

In the model, physical capital, domestic inputs, and all final goods are traded in competitive markets. Conversely, workers, importers, and domestic intermediate goods producers operate as monopolistic competitors, facing either wage or price rigidity akin to the framework proposed by (Calvo, 1983). Consequently, the model incorporates two layers of nominal rigidity. The first layer encompasses the stickiness of input prices, including wages and import prices. The second layer involves stickiness in the prices of intermediate varieties used to produce the four final goods. Consistent with the approach outlined in Christiano et al. (2011), all prices are denominated in the currency of the buyer, a concept known as "pricing to market" which applies even to exports.

The government comprises fiscal and monetary authorities. The fiscal authority imposes lump-sum taxes on optimizing households, provides transfers to firms, and allocates resources for government goods. Additionally, it imposes a tax on the income of rule-of-thumb households, net of government transfers. The majority of transfers in the economy are directed towards lower-income individuals, who typically have limited access to financial and credit markets. To maintain simplicity, the tax structure in the model is kept as straightforward as possible. Furthermore, the government issues domestic bonds, primarily held by optimizing households. Government spending decisions are guided by an empirical fiscal rule, which aims to replicate the actual behavior of the fiscal authority by targeting the primary surplus-to-GDP ratio. On the other hand, the monetary authority aims to stabilize Consumer Price Index (CPI) inflation by adjusting interest rates according to a forward-looking Taylor-type rule, consistent with the inflation targeting framework.

In our model, agents within the domestic economy operate under the assumption that prices and allocations in the global economy are predetermined. To simplify the modeling process, we consider variables describing the rest of the world as exogenous stochastic processes. However, we maintain the underlying assumption that domestic and foreign economies share similar characteristics, including types of agents and production structures. For example, imports from the US serve as inputs for domestic production, while exports contribute to the production processes of foreign firms. The primary linkages between the domestic and global economies stem from international trade in goods, asset markets, and lending activities. Domestic households participate in international financial markets by issuing foreign-currency bonds abroad, while domestic firms utilize foreign-currency loans from overseas sources to finance imports or other external financing needs. We assume that asset markets exhibit incompleteness, and the law of one price does not hold, resulting in imperfect risk sharing and partial exchange rate pass-through in the short run.

5.1 Households

The economy is populated by a mass one of households indexed by $j \in [0, 1]$. The rational efficient households (RE) account for a fraction $1 - \omega_{HM}$ of the population, and hand-to moth households (HM) account for the remaining share. The rational efficient households, unrestricted by financial constraints, make forward-looking decisions regarding consumption, savings, and investment. These households employ a variety of assets or savings instruments - including physical capital, non-contingent one-period government bonds, and non-contingent one-period bonds issued abroad - to smooth their consumption over time. In contrast, hand-to moth households lack access to credit, capital, and asset markets and do not receive firm dividends. They allocate their entire labor income toward consumption goods. Additionally, both types of households provide differentiated labor services, determining their wages in a monopolistically competitive labor market under Calvo-type contracts.

5.2 Rational-Efficient Households

Each rational efficient household, indexed by $j \in RE$, chooses consumption, physical capital and financial assets to maximize the expected discounted flow of utility,

$$\max_{C_{j,t},B_{j,t+1},B*_{j,t+1},K_{j,t+1},I_{j,t}} E_0 \sum_{t=0}^{\infty} \beta^t u\Big(C_{j,t}, N_{j,t},\Big) \tag{5.1}$$

s.t.:

$$P_t^C C_{j,t} + P_t^I I_{j,t} + \frac{B_{j,t+1}}{R_t S_t^B} + \frac{S_t B^*_{j,t+1}}{R_t^* S_t^{B^*}} \\ \leq W_{j,t}^n N_{j,t} + R_t^{K,n} K_{j,t} + B_{jet} + S_t B^*_{jet} + D_{j,t}^n - T_{j,t}^{RE,n} + \Xi_{j,t}^n, \ \forall j \in RE$$

and to the law of motion of capital

$$K_{j,t+1} = (1-\delta)K_{j,t} + \left[1 - S\left(\frac{I_{j,t}}{Z_t^I I_{j,t-1}}\right)\right] I_{j,t}, \tag{5.2}$$

where E_0 is the expectations operator, β is the time discount factor, $C_{j,t}$ is the consumption level, and $N_{j,t}$ is labor. In the budget constraint, P_t^C represents the price of consumption goods, $I_{j,t}$ is the investment, P_t^I represents the price of investment goods, $B_{j,t}$ denotes one-period government domestic bonds, R_t is the domestic gross interest rate, S_t^B is the domestic risk premium, S_t is the exchange rate, $B^*_{j,t}$ represents one-period foreign-currency bonds issued abroad, R_t^* is the external gross interest rate, S_t^* is the country risk premium, $W_{j,t}^n$ is the household-specific nominal wage rate, $R_t^{K,n}$ is is the net nominal rental rate of capital, $K_{j,t}$ is physical capital, $D_{j,t}^n$ denotes nominal dividends from the firms, $T_{j,t}^{RE,n}$ is lump-sum nominal net taxes, $\Xi_{j,t}^n$ are nominal state-contingent securities. We follow the convention that $B_{j,t}$ and $B^*_{j,t}$ represent nominal bonds issued in $t-1$ and maturing in t, $K_{j,t}$ and are capital holdings from $t-1$. So $B_{j,t+1}$, $B^*_{j,t+1}$ and $K_{j,t+1}$ are decided in t. δ represents the depreciation rate of capital in the law of motion of capital, $S(.)$ is a convex adjustment cost, and Z_t^I is an investment-specific technology shock.

We consider the following utility function, augmented by external habit persistence:

$$u(C_{j,t}, N_{j,t}) = Z_t^C \left[\frac{(C_{j,t} - \kappa C_{t-1}^{RE})^{1-\sigma}}{1-\sigma} - Z_t^{1-\sigma} \frac{\psi}{1+\eta} (N_{j,t})^{1+\eta} \right], \tag{5.3}$$

where C_t^{RE} is the average consumption of rational-efficient households, Z_t^C is a shock to the household's intertemporal preference, Z_t is is the level of technology, σ is the inverse of the intertemporal elasticity of substitution, $\psi > 0$ represents a is a weight parameter, κ is a parameter governing the external habit persistence, and η is inverse of labor supply elasticity.

5.3 Hand-to-mouth Households

Hand-to-mouth households just consume their disposable labor income as follows:

$$P_t^C C_{j,t} = (1 - T_t^{HM}) W_{j,t}^n N_{j,t}, \ \forall j \in HM, \tag{5.4}$$

where T_t^{HM} is the marginal net tax rate levied by the government on the labor income of hand-to mouth households.

5.4 Domestic Input Producers

The representative domestic input producer firm operates in perfectly competitive markets and produces the domestic input Y_t^D using a Cobb-Douglas technology using capital and labor:

$$Y_t^D = Z_t^D K_t^{\alpha} (Z_t (N_t - \bar{N}))^{1-\alpha}, \tag{5.5}$$

where K_t is physical capital, N_t is total labor input, $\bar{N}$ is overhead labor, which we assume constant over time, Z_t^D is a domestic transitory technology shock, and Z_t is a stochastic trend embodying permanent shifts in technology.

The temporary technology shock evolves according to an AR(1) process:

$$\log(Z_t^D) = \rho_D \log(Z_{t-1}^D) + \varepsilon_t^D, \tag{5.6}$$

where ε_t^D is the innovation. We define $Z_t^Z = Z_t/Z_{t-1}$ the growth rate of the stochastic trend:

$$\log(Z_t^Z) = (1-\rho_Z)\log(Z^Z) + \rho\log(Z_{t-1}^Z)\varepsilon_t^Z, \tag{5.7}$$

where Z^Z is the long-run growth rate of technology, and ε_t^Z is the innovation.

The domestic input producer takes all prices as given and chooses the optimal amounts of capital and labor services as to minimize total input costs, subject to the technology constraint 5.5:

$$\min_{K_t,N_t}, \left\{R_t^{K,n}K_{,t} + W_t^n N_t - T_t^{D,n} + P_t^D\left(Y_t^D - Z_t^D K_t^\alpha (Z_t(N_t-\bar{N}))^{1-\alpha}\right)\right\}, \tag{5.8}$$

where $T_t^{D,n}$ is a lump-sum transfer from the government, which is equal to the overhead labor cost.

5.5 Sectoral product aggregators

$$Y_t^H = \left(\int_0^1 (Y_{j,t}^H)^{\frac{\epsilon_{H,t}^P - 1}{\epsilon_{H,t}^P}} dj\right)^{\frac{\epsilon_{H,t}^P}{\epsilon_{H,t}^P - 1}}, \tag{5.9}$$

where $H = C, I, G, X$ represents private consumption, investment, government consumption, and exports, Y_t^H is the sectoral output and $Y_{j,t}^H$ is the differentiated product of the intermediate good firm, $\epsilon_{H,t}^P$ is a time-varying elasticity of substitution between the differentiated products. Sectoral product aggregators choose the optimal amounts of each variety and break even in equilibrium. The problem solved by the aggregators firm in sector H is given by:

$$\max_{Y_{j,t}^H}, \left\{P_t^H, Y_{,t}^H - \int_0^1 (P_{j,t}^H Y_{,t}^H dj\right\}, \ \forall H, \forall j \in H, \tag{5.10}$$

subject to equation 5.11 where P_t^H is the aggregate price of home good H, and $P_{j,t}^H$ is the price of intermediate variety j.

5.6 Importing firms

We assume that there is a continuum of importing firms that buy differentiated goods from the rest of the world. Each importing firm buys a distinct variety which is then sold in a monopolistically competitive market to an assembler of imported goods. The assembler transforms the differentiated inputs into a homogenous good, which is sold to domestic intermediate good producers.

$$M_t = \left(\int_0^1 (M_{j,t})^{\frac{\epsilon_M - 1}{\epsilon_M}} dj \right)^{\frac{\epsilon_M}{\epsilon_M - 1}}, \tag{5.11}$$

where M_t is the homogenous imported good, $M_{j,t}$ is the imported variety j and ϵ_M is the elasticity of substitution across products. The importer goods solves the following problem:

$$\max_{M_{j,t}} \left\{ P_t^M M_t - \int_0^1 P_{j,t}^M M_t \; dj \right\}, \tag{5.12}$$

subject to 5.11, where $P_{j,t}^M$ is the price of importing firm, and P_t^M is the aggregate import price

5.7 Foreign Importers

We assume US exports a homogeneous good X_t but it is a differentiated good in the world market. By symmetry with the domestic economy, the US exported good is used as a production input in the rest of the world (ROW). The export assembler ships the US good abroad at the foreign-currency price, $P_t^{X^*}$. In turn, foreign producers combine imports from the US, M_t^* and inputs produced in the ROW, $Y_t^{D^*}$. By symmetry with the domestic economy, the foreign production function is the following:

$$Y_t^* = \left[(\omega^*)^{\frac{1}{\epsilon^*}} \left[\left(1 - \Gamma_t^{M^*} \right) M_t^* \right]^{\frac{\epsilon^* - 1}{\epsilon^*}} + (1 - \omega^*)^{\frac{1}{\epsilon^*}} (Y_t^{D^*})^{\frac{\epsilon^* - 1}{\epsilon^*}} \right], \tag{5.13}$$

where $M_t^* = X_t$, $\epsilon^* > 1$ is is the elasticity of substitution between the US exports and the inputs produced in the ROW. ω^* is the share of US exports in the ROW output bundle, and $\Gamma_t^{M^*}$ is an import adjustment cost, given by:

$$\Gamma_t^{M^*} = \frac{\vartheta^{M^*}}{2} \left(\left(Z_t^{M^*} \right)^{-\frac{1}{\vartheta^{M^*}}} \frac{X_t / Y_t^*}{X_{t-1} / Y_{t-1}^*} - 1 \right)^2, \tag{5.14}$$

with $\vartheta^{M^*} \geq 2$.

The foreign producer chooses the optimal combination of US and ROW inputs as to minimize its total cost:

$$\min_{X_t, Y_t^{D^*}} \left\{ P_t^{D^*} Y_t^{D^*} + P_t^{X^*} X_t \right\}, \tag{5.15}$$

subject to the technology constraint 5.13.

5.8 Law of motion of the government debt

$$P_t^G G_t + B_t = \frac{B_{t+1}}{R_t} + T_t(P_t^Y Y_t) \tag{5.16}$$

5.9 Rest of the World

We do not model the rest-of-the-world economy, but instead assume that foreign variables follow AR(1) processes, describing the dynamics of detrended world income $\bar{Y}_t^*$, foreign inflation $\Pi_t^{C^*}$, foreign investors' risk aversion V_t^*, interest rate R_t^*, and relative price of imports in foreign currency $Q_t^{M^*} \equiv P_t^{M^*}/P_t^{C^*}$

5.10 Asymmetric News shocks

In this setting, the economy is hit by a news shock, $\varepsilon^{\text{news}}_{Z^M_{t-6}}$, on the parameter shifter of the import demand, Z_t^M.

$$\log(Z_t^M) = \rho_{er} \log(Z_{t-1}^M) + \varepsilon_{Z_t}{}^M + a^+ \xi_t \varepsilon^{\text{news}}_{Z^M_{t-1}} + a^-(1 - \xi_t)\varepsilon^{\text{news}}_{Z^M_{t-1}} \tag{5.17}$$

where

$$\xi_t = \begin{cases} 1, & \text{if} \quad \varepsilon^{\text{news}}_{Z^M_{t-1}} > 0 \\ 0, & \text{if} \quad \varepsilon^{\text{news}}_{Z^M_{t-1}} \leq 0, \end{cases}$$

To obtain asymmetry, we follow Azzalini (1985) and we define a as a symmetry shifter drawn from a skew-normal (SN) distribution with skew parameter, λ. If $a > 0$, the a^+ draws represent a right skewed distribution, while if $a < 0$, the draws a^- represent a right skewed distribution.[10]

[10] The skew normal (SN) refers to a parametric class of probability distributions that extend the normal distribution by an additional shape parameter, λ, that regulates the skewness. This parameter allows for a continuous variation from normality to non-normality, such that $\lambda = 0$ corresponds to the standard normal distribution (Azzalini, 1985).

The news shock impacts the economy during its steady state. Agents receive news about a one percent increase in innovations of Z_t^M one period ahead: $\varepsilon^{\text{news}}_{Z^M_{t-1}}$ represents an innovation that materializes in period t but is learned about by agents in period $t-1$.

5.11 Model responses to news shocks

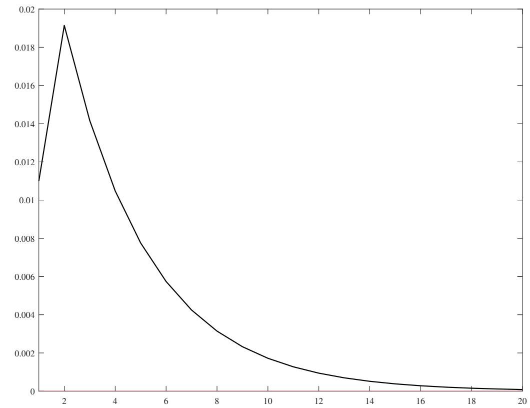
In this section, we present the impulse response functions of imported products, Figures 3 and 4, and inflation, Figures 5 and 6, concerning 'escalating' and 'deescalating' news shocks affecting the parameter shifter of import demand, Z_t^M. Given the substantial contribution of oil to imported products in the US economy, imported products can serve as a suitable proxy for oil prices. Examining the impulse response functions to supply chain disruptions news shocks we gain insights of the ramifications on key economic variables.

An 'escalating news' shock, signaling a tightening or an increasing disruption in the supply chain, typically prompts a series of responses. Initially, there may be an increase in the prices of imported products, Figure 3, particularly those heavily reliant on international supply chains such as oil. This surge in prices could propagate throughout the economy, leading to higher overall inflationary pressures as shown in Figure 5. Furthermore, the impact might extend beyond the first round of immediate price adjustments, influencing consumer behavior, business investment decisions, and overall economic sentiment.

Conversely, an 'deescalating news' shock, indicating a relaxation or improvement in supply chain conditions, would likely lead to contrasting responses. Initially, there might be a stabilization or even a decrease in the prices of imported products, Figure 4, providing some relief from inflationary pressures as shown in Figure 6. This could potentially stimulate consumer spending and business investment, fostering economic growth. However, the extent and duration of these effects would depend on various factors, including the magnitude and persistence of the initial shock and broader macroeconomic conditions.

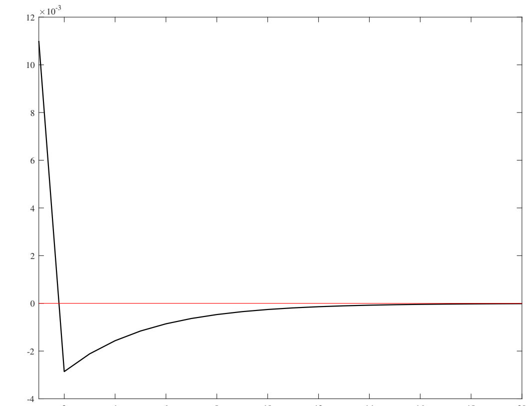
The responses depicted in the theoretical model closely parallel the empirical reactions to supply chain disruptions. Specifically, we note a more pronounced and enduring response to 'escalating' news shocks compared to 'deescalating' ones, characterized by higher amplitude and persistence.

Figure 3: **IRF: Imported products response due to a 'escalating' news' shock**



Notes: IRF: imported products response due to a 'escalating' news' shock.

Figure 4: **IRF: Imported products response due to a 'deescalating news' shock**



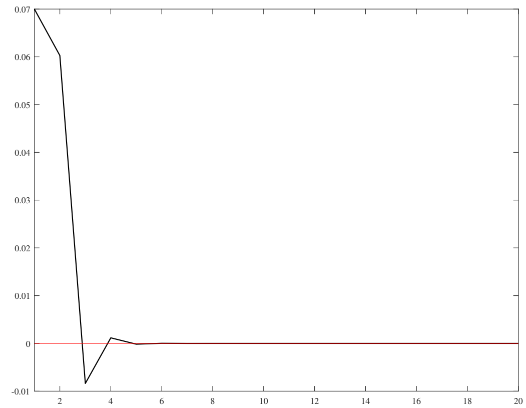
Notes: IRF: imported products response due to a 'deescalating news' shock.

6 Conclusion

In conclusion, this paper raises the question of the 'asymmetry puzzle' of supply chain disruptions news shocks. Our hypothesis is that 'escalating news', indicating tightening of supply chain disruptions may signal larger-scale problems in the supply chain that accumulate over time, causing greater uncertainty and resulting in substantial adjustments in prices and economic behavior. Conversely, 'deescalating news' representing relaxation of supply chain disruptions may indicate temporary or localized disruptions, leading to less significant adjustments in the economy.

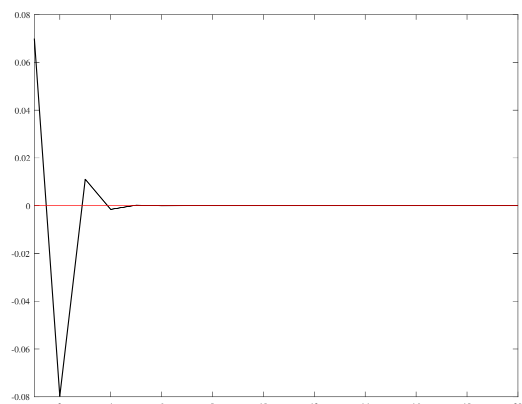
Our study sheds light on the asymmetric nature of supply chain disruption news shocks and

Figure 5: **IRF: Inflation response due to a 'escalating news' shock**



Notes: IRF: inflation response due to a 'escalating news' shock.

Figure 6: **IRF: inflation response due to a 'deescalating news' shock**



Notes: IRF: inflation response due to a 'deescalating news' shock.

their profound influence on economic variables, particularly oil prices and inflation. We hypothesized that the gradual accumulation of news and information regarding supply chain disruptions shapes expectations, influencing consumer and investment decisions, and ultimately contributing to inflationary pressures. Once the identified news shock is decomposed into 'escalating' and 'deescalating' shocks, our findings underscore the critical importance of recognizing the asymmetric effects of supply chain disruptions. Specifically, 'escalating' shocks exhibit more persistent and pronounced impacts than 'deescalating' ones.

Moreover, our research makes significant contributions to the existing literature by investigating the transmission mechanisms of asymmetric supply chain disruption news shocks and their interplay with other macroeconomic factors. Using the Barsky and Sims (2011) estimation approach, we identified the supply chain disruption news shock and decomposed it into 'escalating' and 'deescalating' values, subsequently incorporating them into a VARX model. Through this analysis, we explored the complex interconnection between supply chain disruptions, oil prices, and inflation. Furthermore, we complemented our empirical findings with a theoretical model that aligns with the observed dynamics.

The small open economy model that we propose builds on Castro et al. (2015), augmented with asymmetric news shocks. The model provides a comprehensive framework for assessing the intricate links between the US economy and the global landscape, particularly in light of the segmentation observed in recent years, driven by the integration of the Chinese economy into international trade. This model offers a nuanced understanding of how global supply chain disruption news shocks reverberate through domestic economic variables, thereby aiding policymakers and analysts in navigating the complexities of the interconnected world economy.

Overall, our results offer valuable insights for policymakers and stakeholders seeking to navigate the complexities of the global economy, providing a deeper understanding of the implications of supply chain disruptions and their asymmetric interactions with key economic variables.

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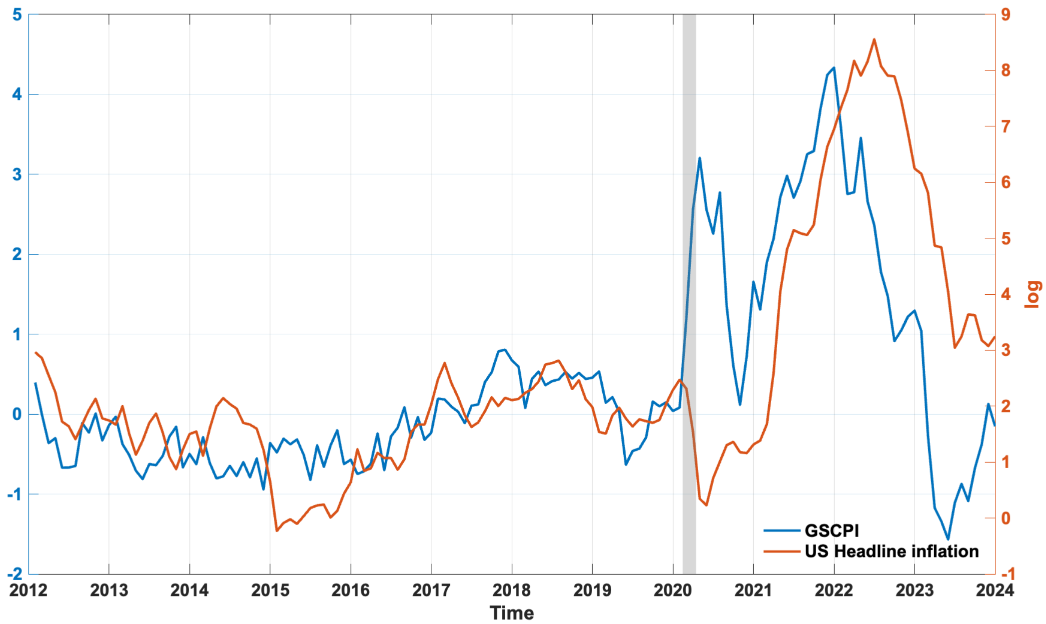
Appendix

A DATA

This section provides a detailed description of the data employed in identifying the news shock related to supply chain disruptions.

Figure A.1: GSCPI vs. US Headline inflation

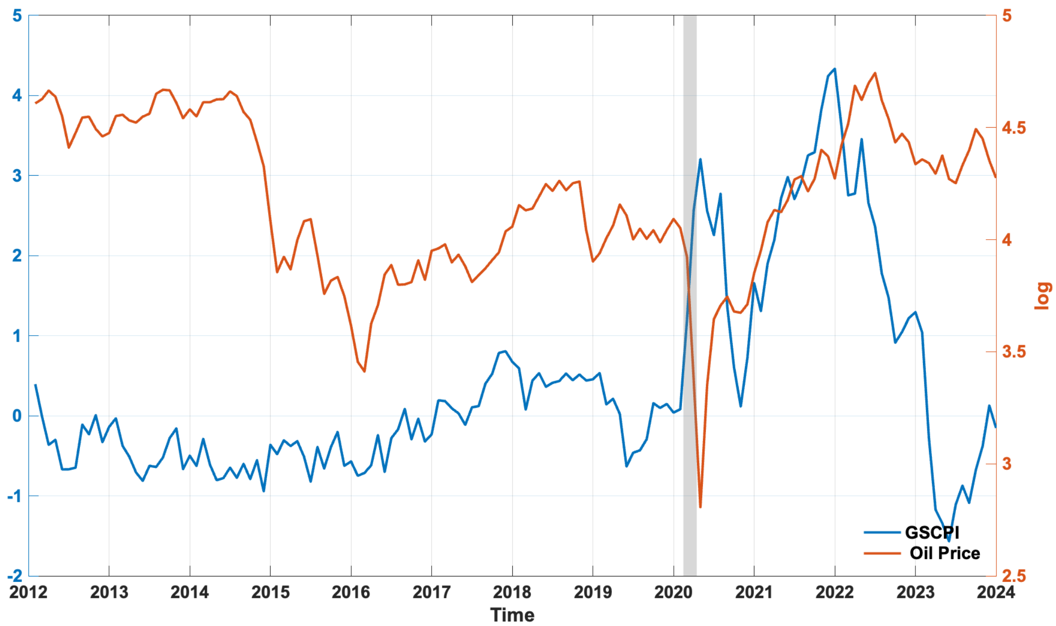


Note: The variables are in logs.

A.1 Global Supply Chain Pressure Index (GSCPI)

The Global Supply Chain Pressure Index (GSCPI) was developed as a parsimonious measure of global supply chain pressures that could be used to gauge the importance of supply constraints with respect to economic outcomes. Changes in the GSCPI are associated with goods and producer price inflation in the United States and the euro area, both during the pandemic period and stretching back to 1997. The GSCPI integrates a number of commonly used metrics with the aim of providing a comprehensive summary of potential supply chain disruptions. Global transportation costs are measured by employing data from the Baltic Dry Index (BDI) and the Harpex index, as well as airfreight cost indices from the U.S. Bureau of Labor Statistics. The GSCPI also uses several

Figure A.2: GSCPI vs. Oil prices



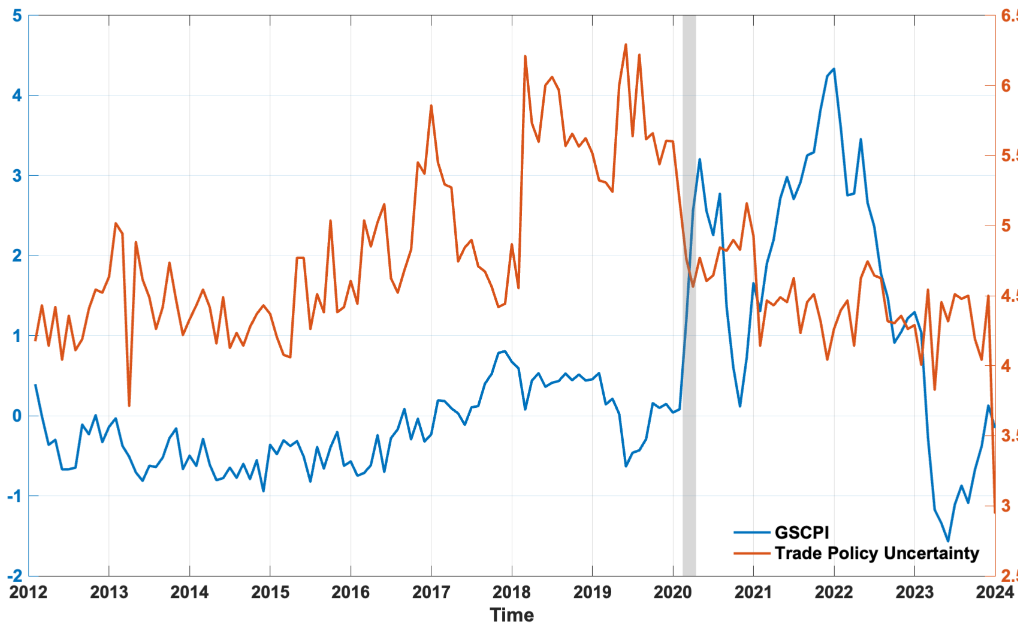
Note: The variables are in logs.

supply chain-related components from Purchasing Managers' Index (PMI) surveys, focusing on manufacturing firms across seven interconnected economies: China, the euro area, Japan, South Korea, Taiwan, the United Kingdom, and the United States. Global Supply Chain Pressure Index (GSCPI)

A.2 Trade Policy Uncertainty Index (TPU Index)

Trade Policy Uncertainty Index developed by Dario Caldara, Matteo Iacoviello, Patrick Molligo, Andrea Prestipino and Andrea Raffo at the Federal Reserve Board. Dario Caldara, Matteo Iacoviello, Patrick Molligo, Andrea Prestipino, and Andrea Raffo construct a monthly index of Trade Policy Uncertainty (TPU Index) by counting the frequency of joint occurrences of trade policy and uncertainty terms across major newspapers. The TPU index spikes initially in the 1970s following the Nixon and Ford "shocks" to U.S. trade policy. There are additional increases in TPU resulting from trade tensions with Japan in the 1980s and around the NAFTA negotiations in the mid-1990s. TPU reaches unprecedented levels beginning after the 2016 U.S. Presidential Election and spikes several times in response to heightened tensions between the U.S. and its trading partners, notably China and Mexico. The paper "The Economic Effects of Trade Policy Uncertainty" constructs three

Figure A.3: GSCPI vs. Trade Policy Uncertainty Index



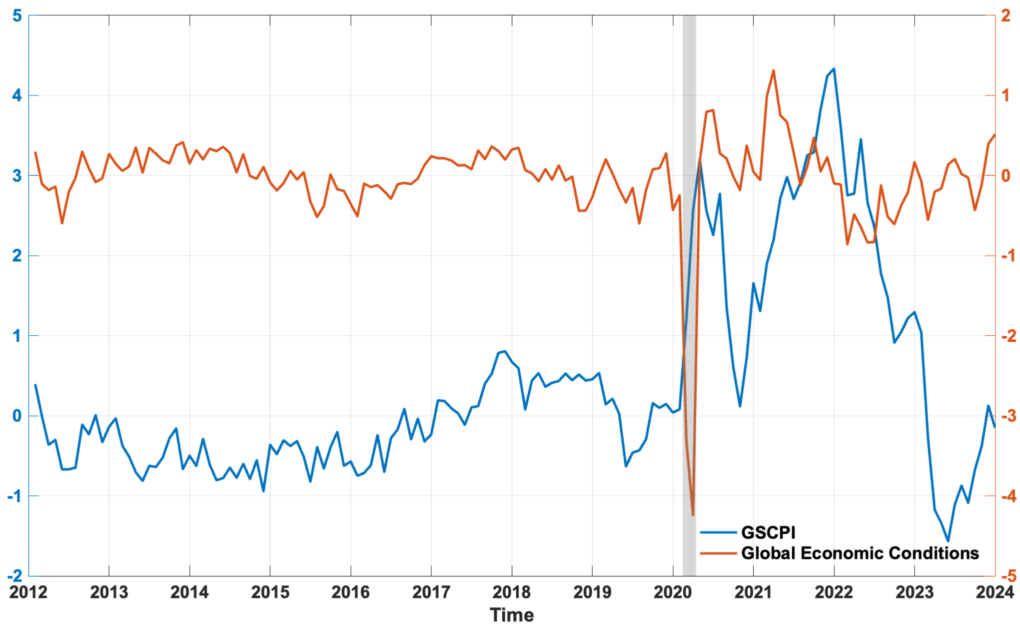
Note: The variables are in logs.

measures of TPU based on newspaper coverage, firms' earnings conference calls, and aggregate data on tariff rates. The paper documents that increases in TPU reduce investment and activity using both firm-level and aggregate data. The paper interprets the empirical results through the lens of a two-country general equilibrium model with nominal rigidities and firms' export participation decisions. In the model as in the data, news and increased uncertainty about higher future tariffs reduce investment and activity. Trade Policy Uncertainty Index

A.3 Global Economic Conditions (GECON)

Global Economic Conditions (GECON) is an indicator of global economic activity and other market fundamentals in terms of their usefulness for forecasting real oil prices and global petroleum consumption. We find that world industrial production is one of the most useful indicators that has been proposed in the literature. However, by combining measures from a number of different sources we can do even better. Our analysis results in a new index of global economic conditions and new measures for assessing future tightness of energy demand and expected oil price pressures. Global Economic Conditions

Figure A.4: GSCPI vs. Global Economic Conditions



Note: The variables are in logs.

A.4 Climate Policy Uncertainty (CPU)

Climate Policy Uncertainty (CPU) Index developed by Konstantinos Gavriilidis in "Measuring Climate Policy Uncertainty". K. Gavriilidis follows the methodology in "Measuring Economic Policy Uncertainty" by Scott R. Baker, Nicholas Bloom and Steven J. Davis. To construct the Climate Policy Uncertainty index, he searches for articles in eight leading US newspapers containing the terms "uncertainty" or "uncertain" and "carbon dioxide" or "climate" or "climate risk" or "greenhouse gas emissions" or "greenhouse" or "CO2" or "emissions" or "global warming" or "climate change" or "green energy" or "renewable energy" or "environmental" and ("regulation" or "legislation" or "White House" or "Congress" or "EPA" or "law" or "policy" (including variants such as "uncertainties", "regulatory", "policies", etc.) from April 1987 onwards. The eight newspapers are: Boston Globe, Chicago Tribune, Los Angeles Times, Miami Herald, New York Times, Tampa Bay Times, USA Today and the Wall Street Journal. For each newspaper, he scales the number of relevant articles per month with the total number of articles during the same month. Next, these eight series are standardized to have a unit standard deviation and then averaged across newspapers by month. Finally, the averaged series are normalized to have a mean value of 100 for the period April 1987 to August 2022. Climate Policy Uncertainty

A.5 FAO Monthly Real Food Price Indices (FFPI)

The FAO Food Price Index (FFPI) is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices weighted by the average export shares of each of the groups over 2014-2016. A feature article published in the June 2020 edition of the Food Outlook presents the revision of the base period for the calculation of the FFPI and the expansion of its price coverage, to be introduced from July 2020. A November 2013 article contains technical background on the previous construction of the FFPI. FAO Monthly Real Food Price Indices

A.6 BHP Group Limited (BHP)

BHP Group Ltd (BHP) is a natural resources company that carries out the exploration, development, production, and processing of mineral resources. It discovers, acquires, and markets various commodities including iron ore, coal, nickel, copper, lead, silver, potash, molybdenum, uranium, zinc, and gold. The commodities produced are transported by rail and road to port and exported to its customers across the world. BHP Group Limited operates as a resources company in Australia, Europe, China, Japan, India, South Korea, the rest of Asia, North America, South America, and internationally. The company operates through Copper, Iron Ore, and Coal segments. It engages in the mining of copper, silver, zinc, molybdenum, uranium, gold, iron ore, and metallurgical and energy coal. The company is also involved in mining, smelting, and refining of nickel; and potash development activities. In addition, it provides towing, freight, marketing and trading, marketing support, finance, administrative, and other services. BHP Group Limited was founded in 1851 and is headquartered in Melbourne, Australia. BHP Group Limited

A.7 Reliance Industries Limited (Reli Ltd.)

Reliance Industries Limited engages in hydrocarbon exploration and production, oil and chemicals, textile, retail, digital, material and composites, renewables, and financial services businesses worldwide. The company produces and markets petroleum products, such as liquefied petroleum gas, propylene, naphtha, gasoline, jet/aviation turbine fuel, kerosene oil, diesel, Sulphur, and petroleum coke. It also provides petrochemicals, including high-density and low-density polyethylene (PE), linear low density PE, polyester fibers and yarns, polypropylene, polyvinyl chloride, purified terephthalic acid, ethylene glycols and oxide, paraxylene, ortho xylene, benzene, linear alkyl benzene and paraffin, poly butadiene rubber, styrene butadiene rubber, butyl rubber, and polyethylene terephthalate. In addition, the company manufactures and markets yarns, fabrics, apparel, and auto furnishings; explores, develops, and produces crude oil and natural gas; and operates various stores comprising neighborhood, supermarket, hypermarket, wholesale cash and carry, specialty, online stores, as well as stores that offer apparel, beauty and cosmetics, accessories, footwear, consumer electronics, connectivity products, and others. Further, the company provides range of digital services under the Jio brand name; and non-banking financial and insurance broking services. Additionally, it operates news and entertainment platforms, and Network18 and television channels; publishes magazines; and offers highway hospitality and fleet management services. Reliance Industries Limited was incorporated in 1973 and is based in Mumbai, India. Reliance Industries Limited

A.8 ITC Limited

ITC Limited engages in the fast-moving consumer goods, hotels, paperboards and paper and packaging, agri, and information technology businesses in India and internationally. It primarily offers cigarettes and cigars; staples, spices, biscuits, confectionery and gums, snacks, noodles and pasta, beverages, dairy, ready to eat meals, chocolate, coffee, and frozen foods; personal care products; notebooks, pens and pencils, geometry boxes, erasers, sharpeners, rulers, wax and plastic crayons, sketch pens, and oil pastels; safety matches; and incense sticks under various brands. In addition, it offers virgin, recycled, barrier, biodegradable barrier, solid, and graphic boards, as well as specialty papers; and packaging products, such as carton board, flexible, tobacco, and green packaging products; and exports feed ingredients, food grains, marine products, processed fruits, coffee products, leaf tobacco products, and spices. Further, the company offers information technology services for the banking, financial services, consumer goods, manufacturing, travel, hospitality, and healthcare industries. Additionally, it provides property infrastructure and estate maintenance; engineering, procurement, and construction management services; project management consultancy services; business consulting, real estate development, and agro-forestry and other related services; manages and operates golf courses; fabricates and assembles machinery for tube filling; cartooning and wrapping services; conveyor solutions; and produces and commercializes seed potato technology products. ITC Limited was incorporated in 1910 and is headquartered in Kolkata, India. ITC Limited

B VAR IDENTIFICATION

We identify news shocks using Barsky and Sims (2011) methodology. Let $\mathbf{y}_t$ be a $k \times 1$ vector of observables of length T. Let the reduced form moving average representation in the (log-)levels of the observables be given as

$$\mathbf{y}_t = \mathbf{B}(\mathbf{L})\mathbf{u}_t \tag{B.1}$$

where $B(L)$ is a $k \times k$ matrix polynomial in the lag operator, L, of moving average coefficients and u_t is the $k \times 1$ vector of reduced-form innovations. We assume there exists a linear mapping between innovations and structural shocks, ε_t, given as:

$$\mathbf{u}_t = \mathbf{A}_0 \varepsilon_t \tag{B.2}$$

This implies the following structural moving average representation:

$$\mathbf{y}_t = \mathbf{C}(\mathbf{L})\varepsilon_t \tag{B.3}$$

Where $\mathbf{C} = \mathbf{B}(\mathbf{L})\mathbf{A}_0$ and $\varepsilon_t = \mathbf{A}_0^{-1}\mathbf{u}_t$. The impact matrix must satisfy $\mathbf{A}_0\mathbf{A}_0^{'} = \mathbf{\Sigma}$, where $\mathbf{\Sigma}$ is the variance-covariance matrix of reduced-form innovations. There are, however, an infinite number of impact matrices that solve the system. In particular, for some arbitrary orthogonalization, $\tilde{A}$ (we choose the convenient Cholesky decomposition), the entire space of permissible impact matrices can be written as $\tilde{A}D$, where D is a orthonormal matrix ($D' = D^{-1}$ and $DD' = I$, identity matrix).

The h step ahead forecast error is:

$$\mathbf{y}_{t+h} - E_{t-1}\mathbf{y}_{t+h} = \sum_{\tau=0}^{h} \mathbf{B}_{\o}\tilde{\mathbf{A}}_0\mathbf{D}\varepsilon_{t+h-\tau} \tag{B.4}$$

where $B\tau$ is the matrix of moving average coefficients at horizon τ. The contribution to the forecasterror variance of variable i attributable to structural shock j at horizon h is then:

$$\Omega_{i,j}(h) = \frac{\mathbf{e}_i' \left(\sum_{\tau=0}^{h} \mathbf{B}_{\o} \tilde{\mathbf{A}}_0 \mathbf{D} \mathbf{e}_j \mathbf{e}_j' \mathbf{D}' \tilde{\mathbf{A}}_0' \mathbf{B}_{\o}' \right) \mathbf{e}_i}{\mathbf{e}_i' \left(\sum_{\tau=0}^{h} \mathbf{B}_{\o} \mathbf{\Sigma} \mathbf{B}_{\o}' \right) \mathbf{e}_i} \tag{B.5}$$

$$= \frac{\sum_{\tau=0}^{h} \mathbf{B}_{i,\tau} \tilde{\mathbf{A}}_0 \gamma \gamma' \tilde{\mathbf{A}}_0' \mathbf{B}_{i,\tau}'}{\sum_{\tau=0}^{h} \mathbf{B}_{i,\tau} \mathbf{\Sigma} \mathbf{B}_{i,\tau}'}$$

The $\mathbf{e}_i$ denote selection vectors with one in the ith place and zeros elsewhere. The selection vectors inside the parentheses in the numerator pick out the jth column of $\mathbf{D}$, which will be denoted by γ. $\tilde{\mathbf{A}}_0\gamma$ is $k \times 1$ is a vector corresponding to the jth column of a possible orthogonalization and has the interpretation as an impulse vector. The selection vectors outside the parentheses in both numerator and denominator pick out the ith row of the matrix of moving average coefficients, which is denoted by $\mathbf{B}_{i,\tau}$.

Let q_t^i occupy the first position in the system, and let the unanticipated shock be indexed by 1 and the news shock by 2. Our identifying assumption implies that these two shocks account for all variation of q_t^i at all horizons. Eqs. (B.5) and (B.4), imply that these two shocks account for all variation in q_t^i

$$\Omega_{1,1}(h) + \Omega_{1,2}(h) = 1 \quad \forall h \tag{B.6}$$

It is general not possible to force this restriction to hold at all horizons. Instead, we propose picking parts of the impact matrix to come as close as possible to making this expression hold over a finite subset of horizons. With the surprise shock identified as the innovation in observed technology, $\Gamma_{1,1}(h)$ will be invariant at all h to alternative identifications of the other $k-1$ structural shocks. As such, choosing elements of A_0 to come as close as possible to making the above expression hold is equivalent to choosing the impact matrix to maximize contributions to $\Gamma_{1,2}(h)$ over h.

Since the contribution to the forecast error variance depends only on a single column of the impact matrix, this suggests choosing the second column of the impact matrix to solve:

$$\gamma* = \arg\max \sum_{\mathbf{h=0}}^{\mathbf{H}} \Omega_{1,2}(h) = \frac{\sum_{\tau=0}^{h} \mathbf{B}_{i,\tau} \tilde{\mathbf{A}}_0 \gamma \gamma' \tilde{\mathbf{A}}_0' \mathbf{B}_{i,\tau}'}{\sum_{\tau=0}^{h} \mathbf{B}_{i,\tau} \mathbf{\Sigma} \mathbf{B}_{i,\tau}'} \tag{B.7}$$

s.t.

$$\tilde{\mathbf{A}}_0(1,j) = 0 \quad \forall j > 1 \tag{B.8}$$

$$\gamma(1,1) = 0 \tag{B.9}$$

$$\gamma'\gamma = 1 \tag{B.10}$$

So as to ensure that the resulting identification belongs to the space of possible orthogonalization of the reduced form, the problem is expressed in terms of choosing γ conditional on an arbitrary orthogonalization, $\tilde{A}_0$. H represents the finite truncation horizon[11]. The first two constraints impose that the news shock has no contemporaneous effect on the level of q_t^i. The third restriction (that γ have unit length) ensures that γ is a column vector belonging to an orthonormal matrix.

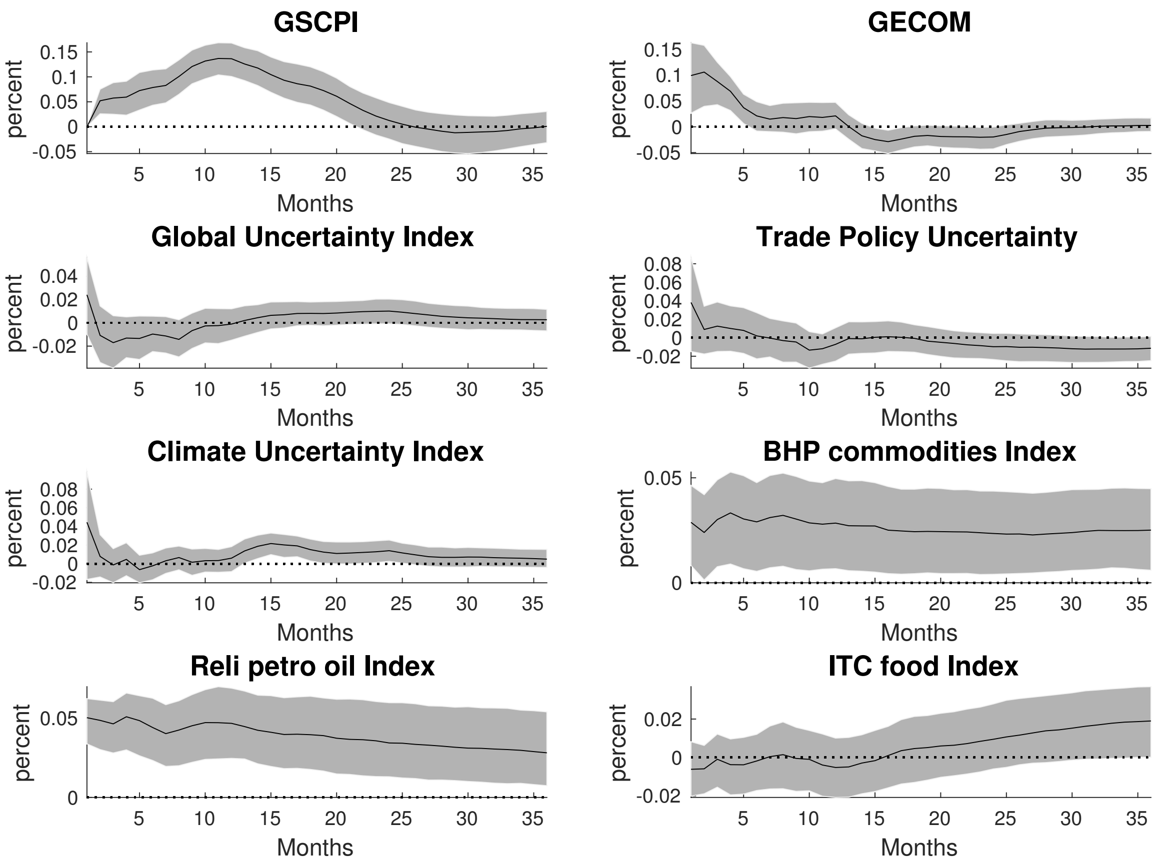
[11]The finite truncation horizon in this paper is 36 periods

C Empirical evidence of GSCPI news shocks

This appendix illustrates the empirical results from a VAR identification of GSCPI news shocks.

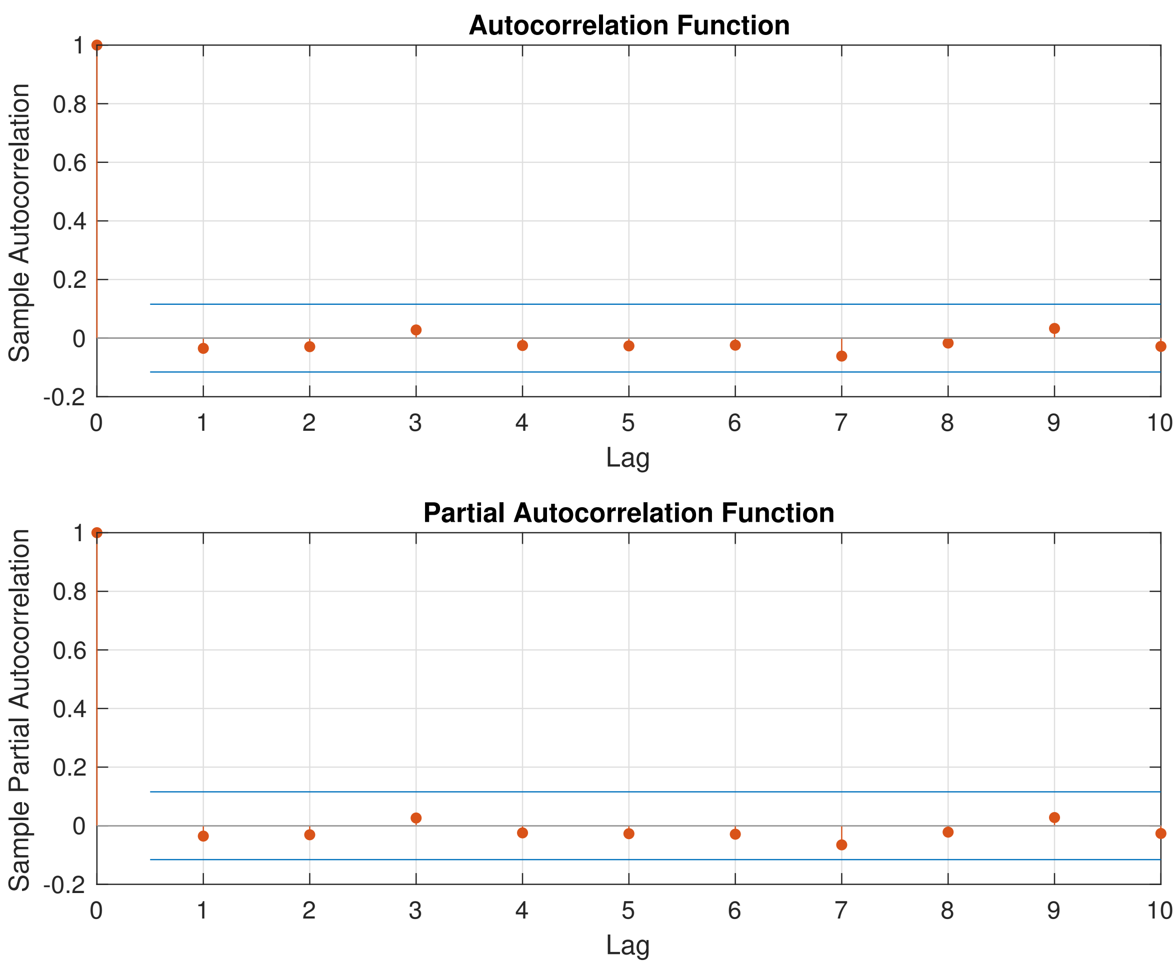
C.1 GSCPI news shock

Figure C.1: IRF from the SVAR identifying the news shock on GSCPI



Notes: Median responses to a news shock on GSCPI (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure C.2: Autocorrelation and partial autocorrelation of the news shock



Notes: Autocorrelation and partial autocorrelation function of the identified news shock using Barsky and Sims (2011) methodology.