The Macroeconomic Effects of Global Supply Chain Shocks

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Abstract

This paper establishes global supply chain shocks as key drivers of business cycle fluctuations, introducing a novel identification strategy based on the narrative analysis of price surcharges from the three largest container shipping companies. Negative shocks cause a persistent rise in consumer prices and a prolonged decline in economic activity. The response is broad-based. Sectoral impacts vary with exposure to global supply chains, measured by the share of inputs sourced from abroad. Spillovers extend to non-tradable sectors. These shocks accounted for up to 51% of the post-pandemic inflation. If there had been only global supply chain shocks with no monetary or fiscal stimulus, recovery would have been delayed by 18 months. Global supply chain shocks explain 35% of the long-run variance of consumer prices and 24% of industrial production over the business cycle.

Keywords: Business Cycles, Global Supply Chain Shocks, Supply Chain Disruptions, Narrative Identification, Post-Pandemic Inflation

JEL Codes: E30, E31, F14, R40

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1 Introduction

The surge in post-pandemic inflation in the United States has sparked an intense debate over its primary causes, with recent literature converging on two broad explanations: demand-driven and supply-driven forces. Several studies, including Giannone and Primiceri (2024) and Bergholt et al. (2024), attribute the price surge to strong pent-up demand, while Jordà and Nechio (2023) emphasize the inflationary impact of direct fiscal transfers. Notably, Hazell and Hobler (2024) estimate that massive fiscal stimulus contributed to a 22–38% increase in the US price level between 2021 and 2022. On the supply side, Bernanke and Blanchard (2023, 2024) identify shocks to energy and food prices, alongside widespread supply disruptions in key sectors, as key inflationary drivers. High-profile events such as the Suez Canal blockage in March 2021 and China's zero-COVID policy, which effectively paralyzed some of the world's busiest ports, have highlighted the fragility of global supply chains. As a result, both the academic literature and policymakers (Tenreyro, 2021; Lane, 2022) increasingly recognize global supply chain shocks as significant contributors to the post-pandemic inflation.

This growing consensus has fueled a broader research agenda aimed at understanding the macroeconomic consequences of global supply chain shocks and their role in driving business cycle fluctuations. A major step in this direction was the development of the Global Supply Chain Pressure Index (GSCPI) by Benigno et al. (2022), which quantifies global bottlenecks using shipping costs, delivery times, and business survey data. Similarly, Bai et al. (2024) introduce a supply chain congestion index based on spatial clustering algorithms to track real-time delays in major ports. Most studies combine these and other indices with structural vector autoregressive (SVAR) models and rely on sign restrictions (Brinca, Duarte and Faria-e Castro, 2021; Bai et al., 2024), narrative-sign restrictions (Finck and Tillmann, 2022; Gordon and Clark, 2023; De Santis, 2024; Ascari, Bonam and Smadu, 2024), or a few exogenous events (Carrière-Swallow et al., 2023) to estimate the dynamic causal effects of supply chain shocks. The prevailing consensus is that global supply chain shocks have

persistent effects on consumer prices, although their impact on the real economy and their precise contribution to the post-pandemic inflation remain subjects of ongoing debate.

However, a key challenge in this literature is that variables such as commodity prices, delivery times, shipping costs, and port congestion are all endogenously influenced by global economic activity (Kilian, 2009; Kilian and Zhou, 2018; Baumeister and Hamilton, 2019; Alquist, Bhattarai and Coibion, 2020; Delle Chiaie, Ferrara and Giannone, 2022; Baumeister, Korobilis and Lee, 2022). This complicates causal inference, as these indicators conflate the effects of supply chain disruptions with those of other macroeconomic shocks. Moreover, identifying truly exogenous supply chain disruptions is inherently challenging, given their diverse and global nature, which encompasses extreme weather events, labor strikes, port closures, geopolitical conflicts, and piracy.

In this paper, I propose a new identification strategy for global supply chain shocks by narrative analysis of price surcharge announcements from the three largest containerized shipping companies, which collectively hold nearly 50% of the market share and up to 70% through strategic alliances. I collect approximately 7,000 daily price and surcharge updates published on their websites from 2014 to 2024, focusing exclusively on five key regions: Europe, the Middle East and Sub-Indian Continent, East Asia, Oceania, and North America. These updates range from general freight increases to other extraordinary surcharges influenced by supply and demand dynamics, expectations, and strategic behavior. While the announcements often reflect both supply and demand factors, when surcharges arise from extraordinary, unpredictable events, the companies frequently cite explicit reasons. Using a keyword-based algorithm adapted from Baker, Bloom and Davis (2016), I first isolate a subset of 369 surcharge announcements that contain terms objectively associated with exogenous supply-side events, such as strikes, natural disasters, armed conflicts, piracy and operational disruptions. I then conduct a narrative analysis of these announcements, cross-validating them with external sources, in an adaptation of the narrative identification strategy widely employed in the study of oil shocks (Hamilton, 1985, 2003; Caldara, Cavallo and Iacoviello,

2019), monetary policy shocks (Romer and Romer, 2004; Aruoba and Drechsel, 2024), and fiscal shocks (Ramey and Shapiro, 1998; Romer and Romer, 2010; Ramey, 2011). This process allows me to identify 62 exogenous supply chain disruptions, measured as price surcharges in US dollars per Forty-foot Equivalent Unit (FEU) dry container. Some represent large-scale disruptions that impact cargo flows through major maritime chokepoints, such as the Suez and Panama Canals, the Bab el-Mandeb Strait, and the Strait of Hormuz, or affect all ports along key global trade routes, including the Trans-Pacific, East–West, and Trans-Atlantic routes. Others are more localized in scope, including disruptions at some of the world's busiest ports, among others, Shanghai, Ningbo, Los Angeles–Long Beach, Nhava Sheva, and Colombo, as well as disruptions affecting all ports within a country, as in the case of nationwide transport strikes.

Using the FEU price surcharges as an external instrument in a Proxy-SVAR framework, I estimate the dynamic causal effect of global supply chain shocks on the US economy, both at aggregate and sectoral levels. My findings reveal that these shocks are stagflationary, leading to a persistent rise in consumer prices and a more persistent economic slowdown than previously thought, marked by reduced industrial production and elevated unemployment. In line with standard New Keynesian cost-push dynamics, these disruptions raise transportation costs and impair the delivery of intermediate goods, which raises firms' marginal costs. This reduces profit margins, causing firms to scale back production and lower labor demand, which raises unemployment and drives consumer price increases through nominal friction mechanisms.

At the sectoral level, I find declines across all production sectors, with sustained increases in all consumer price categories. Sectoral output dynamics mirror aggregate responses: an initial decline, peaking within the first few quarters, and a gradual return to steady state over three years. However, the magnitude of these effects varies across sectors. A sector's exposure to global supply chains, measured by the share of intermediate inputs imported from abroad (Baldwin, Freeman and Theodorakopoulos, 2023), explains this heterogeneity.

I find that greater exposure is associated with more severe production declines. Moreover, sectors that experience the largest output reductions also exhibit the most significant and persistent pass-through to consumer prices. Importantly, I also document significant spillover effects into non-tradable service sectors. Although services are not directly exposed to global supply chains, they respond to the slack created by the broader decline in the production side of the economy. As the contraction deepens, service activity and employment decline with a lag, and the magnitude of the response is more muted compared to the tradable sector.

My sectoral analysis highlights why global supply chain shocks differ fundamentally from other cost-push shocks, such as oil supply shocks, undoubtedly the most studied in the literature. Oil shocks generate highly heterogeneous sectoral production responses, driven by factors like energy intensity in production, energy intensity of the goods produced, and demand substitutability (Davis and Haltiwanger, 2001; Hamilton, 2003; Herrera, Lagalo and Wada, 2011). Most industrial sectors show limited output responses to oil shocks, with price effects varying: some consumer price categories exhibit persistent increases, others are transitory, and some remain unaffected (Tenreyro, 2022; De Santis, 2024). In contrast to oil supply shocks, whose effects can be mitigated through the Strategic Petroleum Reserve or via the International Energy Agency cooperation, global supply chain disruptions lead to widespread output losses due to the physical unavailability of intermediate inputs sourced from abroad. This type of risk is fundamentally unhedgeable. While firms may receive monetary compensation for delays and can insure against fluctuations in shipping costs, they cannot insure against the missing deliveries of intermediate inputs, which disrupts production across all sectors. This results in persistent, broad-based CPI increases, with many categories still elevated four years post-shock. These findings suggest a clear policy implication: while Guerrieri et al. (2023) suggest central banks should overlook oil supply shocks due to their transitory nature, the prolonged impact of supply chain disruptions implies that prompt policy responses are essential to mitigate persistent inflationary pressures.

I also contribute to the debate about the main causes of the post-pandemic inflation. My estimates indicate that global supply chain shocks were the primary driver of inflation in 2021, accounting for an average of 51% of the price increase. While my analysis does not rule out the significant role of demand, it shows that global supply chain shocks were the primary contributors in the early stage of the price surge in 2021. From 2022 onward, other factors, such as demand forces, fiscal stimulus, and shocks to productive capacity (Goda and Soltas, 2022; Hobijn and Sahin, 2022; Lee, Park and Shin, 2023), increasingly shaped inflation dynamics. Nevertheless, global supply chain shocks remained a significant force, contributing 32%, 30%, and 22% to consumer price increases in 2022, 2023, and 2024, respectively. Regarding economic recovery, these shocks exerted sustained downward pressure, with a peak impact in November 2021, when they caused a 7.5% decline in industrial production relative to pre-pandemic levels. In a counterfactual scenario with only global supply chain shocks, industrial production would have required an additional 18 months to return to pre-pandemic levels, from November 2021 to May 2023.

Beyond their role in the post-pandemic period, I show that global supply chain shocks are a key driver of business cycle fluctuations. The identified structural shocks account for the bulk of short- and medium-term movements in the GSCPI, as they isolate the primitive exogenous sources behind its variation. I further find that these shocks explain more than one-third of consumer price variability, a quarter of industrial production variability, and about 10% of unemployment variability over the business cycle.

While finalizing this paper, I learned of Känzig and Raghavan (2025)'s measure of supply chain disruptions constructed from high-frequency movement of the Baltic Exchange Dry Index during exogenous events at the Panama and Suez Canals. Their instrument captures shocks to low-value dry bulk commodities, unlike my measure, which reflects disruptions to a wide range of high-value containerized goods spanning intermediate and final products. Their measure also has a narrower geographic focus, excluding major trade corridors like the Trans-Pacific, Trans-Atlantic and key Asian hubs. Given these differences, one might

expect their estimates to confirm stagflationary effects but yield a more muted industrial production response, and a smaller contribution to post-pandemic inflation and economic recovery.

The remainder of the paper is organized as follows: Section 2 discusses the identification design and the construction of the instrument. Section 3 outlines the econometric approach and examines the propagation of global supply chain shocks at aggregate and sectoral levels. Section 4 evaluates their cumulative impact on pandemic-era inflation and economic recovery. Section 5 assesses the quantitative role of global supply chain shocks as drivers of business cycle fluctuations. Section 6 performs some robustness checks, and Section 7 concludes.

2 Narrative Identification

The identification strategy builds on the narrative analysis of surcharge announcements from the world's three largest shipping companies. When confronted with exogenous disruptions that increase operational costs, shipping companies respond by imposing price surcharges on shippers. The idea is to construct a series of price surcharges correlated exclusively with exogenous supply-side disruptions that will serve as an external instrument in a SVAR framework to structurally identify the unobserved global supply chain shocks. Before detailing the procedure for identifying such disruptions, I first provide evidence on the containerized shipping market's oligopolistic structure and the role played by price surcharges in the measurement and transmission of shocks across the supply chain network.

2.1 The Containerized Shipping Industry

From 2014 to 2024, the containerized shipping industry was dominated by three major alliances: the 2M Alliance, formed by Mediterranean Shipping Company (MSC) and A.P. Møller–Mærsk A/S (Maersk); the Ocean Alliance, comprising Compagnie Maritime d'Affrètement–Compagnie Générale Maritime (CMA CGM), COSCO, and Evergreen; and THE

Alliance, including Hapag-Lloyd, Ocean Network Express (ONE), Yang Ming Marine Transport Corporation, and Hyundai Merchant Marine (HMM). These alliances collectively controlled approximately 80-90% of global container shipping capacity by the early 2020s, reflecting the concentrated structure of the industry and enabling carriers to coordinate vessel deployment, share terminal infrastructure, and reduce route duplication, thereby achieving significant economies of scale. High fixed costs, substantial barriers to entry, and the need for globally integrated service networks reinforced market power among a small group of dominant carriers. The three largest shipping companies, MSC, Maersk, and CMA CGM, together account for nearly 50% of the global container shipping market, with operations that span all major trade corridors, from Asia to Europe, North America, and beyond.

Crucially, the interconnectedness of major trade lanes, including the East-West, Trans-Pacific, and Trans-Atlantic corridors, effectively creates a de facto single global shipping route. Vessels routinely interconnect at major hubs such as Singapore, Shanghai, Rotterdam, and Los Angeles–Long Beach, transforming the global network into an integrated and interdependent system (Fan, Wilson and Dahl, 2012). As a result, disruptions in one region, such as the 2021 Suez Canal blockage or the 2022 Shanghai port backlog, quickly reverberated across the entire network, generating ripple effects on capacity, schedules, and freight pricing worldwide.

Within this tightly interconnected system, shipping companies respond to demand or supply shocks by imposing price surcharges on shippers. These surcharges serve as a key mechanism to recover rising operational costs and, at the same time, to rebalance container flows by disincentivizing shipments into already congested or container-saturated regions. However, because surcharges are typically applied across entire trade lanes, a localized disruption, originating in, say, a single port or country, can lead to system-wide price increases, affecting routes far removed from the original shock. In this way, price surcharges function as transmission vehicles: they not only quantify the magnitude of the disruptions but also propagate the increasing operational costs across multiple trade lanes through the combined

forces of oligopolistic power and network interdependence. MSC, MAERSK, and CMA CGM published more than 7,000 price and surcharge updates on their websites between February 2014 and December 2024, reflecting changes in container shipping costs across a wide range of global routes and ports. I will now describe the methodology used to isolate exogenous supply-side disruptions to the global supply chain from the narrative record of price surcharges.

2.2 Identifying Exogenous Disruptions

Methodology.— To construct a narrative-based measure of exogenous global supply chain disruptions, I begin by systematically collecting price surcharge announcements from the websites of the three largest container shipping companies. Specifically, I compile 1,218 surcharges from MSC (February 2014–December 2024), 2,450 from Maersk (March 2019–December 2024), and 3,222 from CMA CGM (March 2015–December 2024). These announcements include various surcharge types, often accompanied by textual justifications provided by the carriers themselves.

I focus exclusively on surcharges related to the three major trade routes, Trans-Pacific, East-West and Trans-Atlantic corridors, which form a unified global shipping network. I exclude routes serving South America and West Africa, as well as surcharges involving ports with annual throughput below 250,000 FEUs, which are less relevant for capturing globally systemic disruptions.

To isolate surcharges only related to exogenous supply-side disruptions, I adopt a keyword-based algorithm adapted from Baker, Bloom and Davis (2016). Using a pre-defined list of terms associated with operational failures, labor strikes, natural disasters, geopolitical conflicts, and partial or full blockages of maritime chokepoints with consequent re-routing (see online Appendix B), I isolate a subset of 369 surcharge announcements that contain one or more terms plausibly linked to unpredictable supply-side disruptions.

Following this automated screening, I conduct a narrative analysis of the explanation

accompanying each of the 369 candidate surcharge announcements to verify that it reflects an exogenous supply-side disruption unrelated to broader macroeconomic or demand-driven forces. When the textual description is insufficiently detailed, I cross-validate the announcement using external sources such as local newspapers, industry blogs, and port authority statements.

Applying the criteria.— For illustration, I include below a price surcharge announcement published by Maersk on January 8, 2024, which suspended transit through the Red Sea due to multiple Houthi rebel attacks on commercial vessels, rerouted vessels via the Cape of Good Hope, and introduced a Transit Disruption Surcharge (TDS):

> ***08 January 2024 – Transit Disruption Surcharge***
>
> *As we have been communicating since mid-December/23, Maersk is continuing monitoring developments around the Red Sea / Gulf of Aden and making carefully considered changes to services to ensure the safety of our seafarers, vessels and customers' cargo.*
>
> *The situation is constantly evolving and remains highly volatile, and all available intelligence at hand confirms that the security risk continues to be at a significantly elevated level. We have therefore decided that all Maersk vessels due to transit the Red Sea / Gulf of Aden will be diverted south around the Cape of Good Hope for the foreseeable future.*
>
> *By suspending voyages through the Red Sea / Gulf of Aden, we hope to bring our customers more consistency and predictability despite the associated delays that come with the re-routing.*
>
> *The previously announced surcharges for all cargo on vessels affected by the disruptions around the Red Sea / Gulf of Aden remain in effect:*
>
> *Transit Disruption Surcharge effective as from actual sailing date 10/01/2024*

until further notice.

To give you as much clarity and predictability as possible, TDS will apply only to bookings confirmed as from 21/12/2023 (global announcement date) and departure date as from 10/01/2024 onwards.

TDS - USD per container	**20DRY**	**40DRY**	**40HREF**
All shipments diverted from Suez	200	400	450

The narrative analysis of the surcharge establishes its exogenous supply-side cause. When the announcements lack explicit reasons for the surcharge, I complement the narrative analysis of the announcement with external sources to assess whether an exogenous supply-side disruption is plausibly the cause of the surcharge. For example, CMA CGM introduced a Port Congestion Surcharge (PCS) on March 27, 2023, for shipments departing from Mersin, Turkey:

27 March 2023 – PCS in Mersin, Turkey

We inform our customers that we are experiencing important delays in Mersin, Turkey between congestion/waiting time plus berth time on the current vessels berthing sequences with following impacts: (i) laden cargo lead-time is being increased; (ii) empty equipment re-loading / repositioning frequency is affected; (iii) operating costs are increased.

In this respect please be informed that CMA CGM will be implementing a Port Congestion Surcharge in Mersin as follows:

- ***From:*** *Mersin, Turkey*
- ***To:*** *Mediterranean & Adriatic, Black Sea, North Africa & Portugal, South America, Central America & Caribbean, Mexico West Coast, Windward, Guyana North Brazil, Middle East Gulf, Red Sea, North & South East Asia, China, Hong Kong SAR*

- ***Cargo:*** *Dry*
- ***Applicable from:*** *March 27th, 2023, loading date (April 25th, 2023 for Puerto Rico)*
- ***Amount:*** *USD 100 per TEU*

Although CMA CGM did not specify the reason for the PCS, I classify this surcharge as a response to an exogenous supply-side disruption. Several sources confirmed that the cause of the surcharge was a devastating 7.8-magnitude earthquake that struck southern Turkey in February 2023, causing extensive damage to port infrastructure and regional road networks.[1] Trucking activity around Mersin was largely disrupted, and the major nearby port of Iskenderun ceased operations due to fire damage caused by the earthquake. As a result, vessels were rerouted to Mersin, leading to increased delays and congestion.

Morphology of exogenous disruptions.— Overall, the narrative analysis leads to the identification of 62 exogenous disruptions. Among these, 14 events involve major maritime chokepoints, where disruptions affect all trade routes transiting through them. These include four weather-related disruptions at the Panama Canal, driven by prolonged drought and reduced water levels; four operational disruptions at the Suez Canal, caused by the 2021 grounding of the Ever Given and other blockage-related incidents; one conflict-related disruption in the Strait of Hormuz, linked to an Iranian attack on two oil tankers; and four war-related events at the Bab el-Mandeb Strait, all stemming from Houthi rebel attacks and the broader civil conflict in Yemen. Beyond chokepoints, 8 additional events involve all ports along major trade corridors. These include disruptions on routes connecting Far East Asia (China, Taiwan, Hong Kong) to the United States and Europe, as well as five events along the Trans-Atlantic corridor, primarily caused by low water levels in the St. Lawrence

[1] See: Portcast (2023): *Impact of Türkiye–Syria Earthquake on the Shipping Industry*, Fox Business (2023): *Earthquake Sparks Massive Shipping Container Fire*, and Reuters (2023): *Iskenderun Port Operations Halted After Earthquake-Induced Fire*.

Seaway. An additional 13 disruptions affect broader macro-regions, involving multiple ports or inland transport systems within the same country or trade area. These include, among others, a nationwide breakdown in India's inland transport system due to truck driver shortages; widespread disruptions across dry ports in the United States; strikes in southern France and nationwide in Spain; labor unrest in northern European ports (Le Havre and Dunkirk); operational challenges across all UK ports; and war-related disruptions to all Black Sea trade ports following Russia's invasion of Ukraine. Finally, 27 events are localized at individual ports, including high-traffic terminals such as Shanghai, Ningbo, Los Angeles–Long Beach, Felixstowe, Nhava Sheva, and Colombo, affected by either operational failures or strikes.

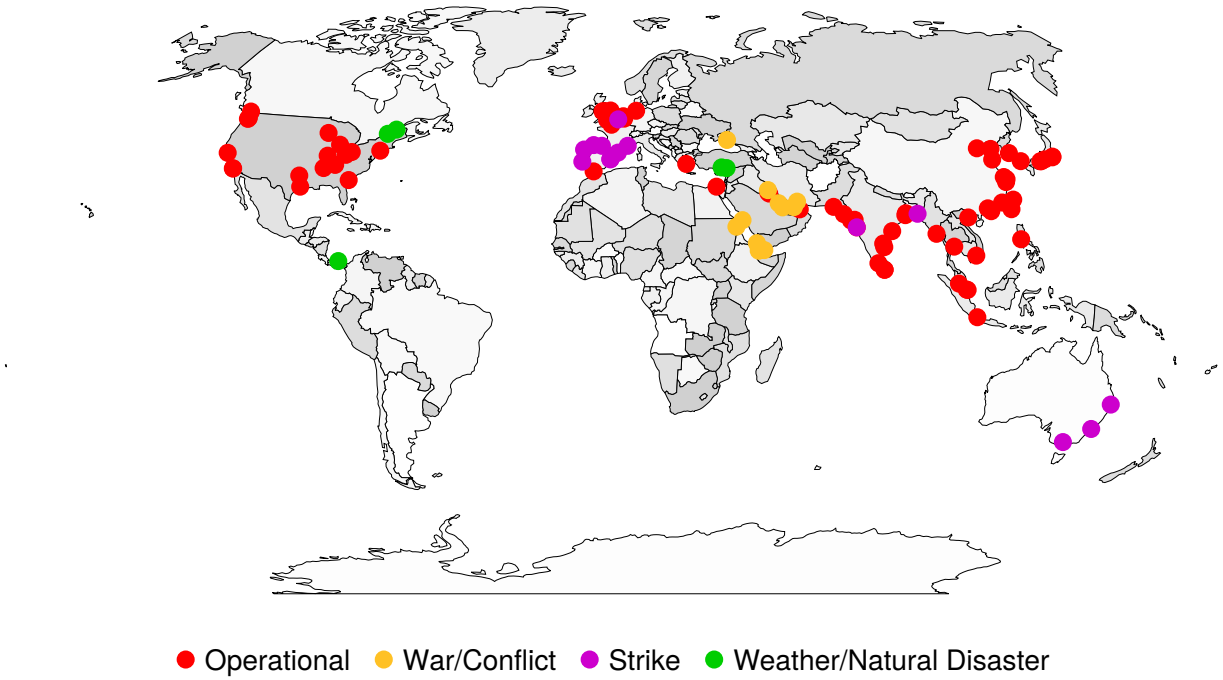


Figure 1: Sea and Dry Ports Involved in Congestions and Other Disruptions.

These disruptions are classified into four categories based on their underlying cause: operational, war and conflict, strikes, and extreme weather or natural disasters. Figure 1 illustrates the global distribution of identified supply chain disruptions, with each event categorized by its underlying cause. For disruptions affecting entire trade routes, only the busiest ports, measured by annual container throughput in FEUs, are shown to preserve

visual clarity.

Operational disruptions, comprising nearly 53% of the total (33 events), include truck driver shortages, new port regulations increasing vessel and container processing times, infrastructure failures (e.g., crane breakdowns or bridge collapses), and full or partial blockages of strategic chokepoints. War and conflict-related disruptions account for 18% of events and involve port closures due to hostilities, particularly in the Middle East, and suspensions of trade routes in war zones, such as the Black Sea. Strikes represent 11% (7 events), comprising labor actions that affected port operations either locally or nationally. Finally, natural disasters and extreme weather events, including exceptionally low water levels in the St. Lawrence seaway, the El Niño phenomenon impacting the Panama Canal, and the devastating earthquake in Turkey, constitute the remaining 18% of the total disruptions. An overview of all surcharge dates and data sources can be found in the online Appendix B.

2.3 Construction of the Instrument

Size and timing.— Building on the previously identified exogenous disruptions and their associated price surcharges, I now proceed with the construction of the narrative-based time series. For each disruption event, I first compute the average surcharge across affected trade lanes and shipping companies. These event-level averages are then aggregated within the month in which the surcharges were implemented, producing a cumulative monthly surcharge series measured in US dollars per FEU container.

In most cases, surcharges are applied either immediately or within the same month as the corresponding announcement. When implementation occurs in the following month, I assign the surcharge to the month of the implementation. This choice is motivated by several factors. Unlike central banks or institutions such as OPEC, shipping companies communicate pricing decisions less clearly and with limited coordination. Moreover, there is no evidence that market participants actively monitor or react to these announcements in real time. Even if such monitoring were to occur, substituting containerized ocean freight with

alternative modes of transport, such as air freight, is both costly and logistically challenging. In addition, the contractual terms of container shipping are typically fixed well in advance, often for periods exceeding one year, further limiting the scope for anticipatory adjustments. These features of the industry imply that the demand for containerized shipping is relatively inelastic in the short run and that news effects are minimal. In the few cases where different carriers issue surcharges related to a single event across two consecutive months, I assign the event to the later month if most implementations occur after the midpoint of the earlier month.

The price surcharge series.— Figure 2 displays the resulting time series of price surcharges, expressed in US dollars per FEU dry container. This series represents a partial but timely measure of cumulative, exogenous supply-side disruptions in the global shipping network. Constructed at a monthly frequency over eleven years, it contains 46 non-zero observations corresponding to 62 individually identified disruption events. Of these, 19 events (approximately 40 percent) occurred before January 2020. It is worth noting that price surcharge data from Maersk are only available from January 2019 onward.

Among the identified exogenous price surcharges, only three negative values appear, each reflecting unexpected improvements in shipping conditions. These include the removal of the port congestion surcharge in Yemen in April 2018, following a UN-led conference that secured $2 billion in aid and introduced an economic plan to enhance humanitarian access and logistics; infrastructure upgrades at Shuwaikh Port in Kuwait in June 2019, where rapid progress on a berth development project reduced congestion and delays; and improvements in inland transportation and dry port operations in India in February 2023, where recent legislative reforms in customs and logistics policy spurred investment in freight infrastructure and centralized warehousing, including the completion of over 1,700 kilometers of high-capacity Dedicated Freight Corridors.

The largest positive surcharge, 1,340 dollars, was recorded in December 2020, driven by

multiple concurrent shocks: a second wave of COVID-19 severely reduced port and trucking labor availability in the United States and the United Kingdom; newly introduced sanitation protocols for container handling in both countries further lengthened operational times; and the escalation of the Yemeni conflict caused additional disruptions in the Bab el-Mandeb Strait.

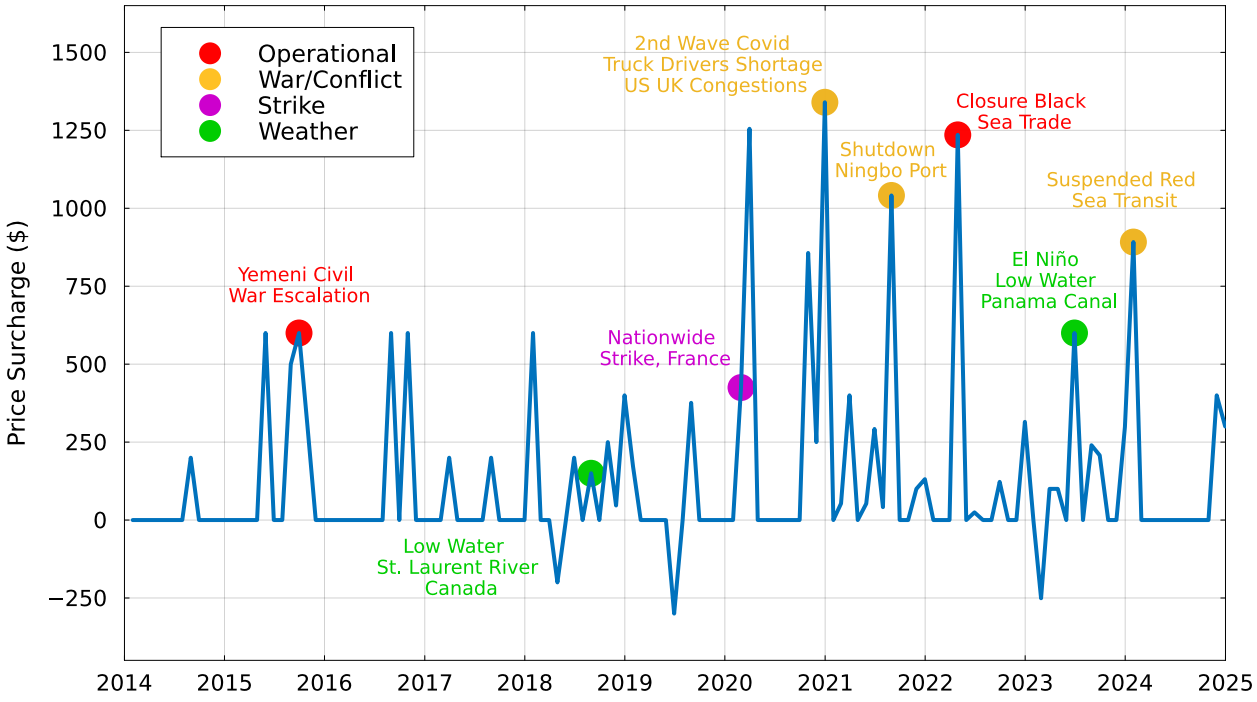


Figure 2: The Dry FEU Price Surcharge Series.

Overall, the FEU price surcharge series closely aligns with major narrative episodes of disruption. Figure 2 highlights several major events in the container shipping network. These annotated episodes span each of the four disruption categories defined earlier: geopolitical conflict (e.g., the Yemeni civil war and Black Sea trade restrictions), operational failures (the August 2021 shutdown of Ningbo's Meishan terminal due to a COVID-19 outbreak), extreme weather events (e.g., El Niño-related congestion in the Panama Canal and low water levels in the St. Lawrence River), and labor strikes (e.g., the nationwide strike in France affecting all forms of transport). While these events represent only a subset of the 62 disruptions identified through the narrative analysis, they demonstrate that the FEU price surcharge

series aligns closely with widely recognized, unpredictable supply chain disruptions.

Diagnostics— I perform a series of diagnostic checks on the FEU price surcharge series, examining autocorrelation, Granger causality in relation to a series of macroeconomic variables, and correlation with other structural shocks, following the approach outlined in Ramey (2016). I find no evidence of serial correlation: the p-value for the Ljung–Box Q-statistic testing whether all autocorrelations up to lag 20 are jointly zero is 0.39. I also find no evidence that the FEU price surcharge series is forecastable using a set of macroeconomic variables and other indicators that capture global uncertainty, trade, and geopolitical risk. The p-values from the Granger causality tests are well above conventional significance thresholds. Finally, I verify that the series is uncorrelated with other structural shock measures commonly used in the literature, including oil demand shocks, global economic activity shocks, and monetary policy shocks. All the results are available in the online Appendix A.

In Section 6, I further demonstrate that the results are not driven by any specific individual or subset of events. In particular, the main findings remain unchanged when excluding each disruption category individually, operational disruptions, wars and conflicts, labor strikes, and extreme weather events, as well as when excluding all COVID-related events.

3 Global Supply Chain Shocks & Business Cycle

The FEU price surcharge series can be seen as a partial measure of the unobserved global supply chain shock. Provided that this narrative-based series is correlated with the global supply chain shock and uncorrelated with other structural shocks affecting the economy, I use it as an external instrument within a Vector Autoregression (VAR) framework. This approach, also known as a Proxy-SVAR or SVAR-IV, focuses exclusively on identifying the structural shock of interest and builds on the extensive literature on the identification of structural VARs using external sources of exogenous variation, as developed by Stock (2008),

Mertens and Ravn (2013), Stock and Watson (2018), and Montiel Olea, Stock and Watson (2021).

3.1 Econometric Framework

Consider the stationary reduced-form VAR(p) model:

$$\boldsymbol{y}_t = \boldsymbol{\Pi}\boldsymbol{x}_{t-1} + \boldsymbol{\epsilon}_t. \tag{1}$$

The k x 1 vector $\boldsymbol{x}_{t-1} = (\mathbf{1}, \boldsymbol{y}'_{t-1}, \ldots, \boldsymbol{y}'_{t-p})'$ contains an intercept and p lags of each of the variables ($k = 1 + pn$) and $\boldsymbol{\epsilon}_t$ is an n x 1 vector of reduced form innovations such that $\boldsymbol{\epsilon}_t \sim (\mathbf{0}, \boldsymbol{\Omega})$. The n x k matrix of reduced-form coefficients $\boldsymbol{\Pi}$ is estimated by OLS. I now assume that the model is invertible, i.e. the reduced-form innovations are a linear combination of the structural shocks:

$$\boldsymbol{\epsilon}_t = \boldsymbol{A^{-1}}\boldsymbol{u}_t. \tag{2}$$

where $\boldsymbol{A^{-1}}$ is the n x n structural impact matrix and $\boldsymbol{u}_t$ is the n x 1 vector of mutually uncorrelated structural shocks, i.e. $\boldsymbol{u}_t \sim (\mathbf{0}, \boldsymbol{D})$, where $\boldsymbol{D} = diag(d_{11} \ldots d_{nn})$. In Section 6, I formally test the invertibility assumption using the procedures outlined in Plagborg-Møller and Wolf (2022) and Hamilton (Forthcoming), and fail to reject the null hypothesis of invertibility for the baseline empirical model. The invertibility assumption implies

$$\boldsymbol{\Omega} = \boldsymbol{A^{-1}}\boldsymbol{D}(\boldsymbol{A^{-1}})'. \tag{3}$$

Since the VAR is stationary, (1) yields a VMA(∞) representation of the form

$$\boldsymbol{y}_t = \sum_{h=0}^{\infty} \boldsymbol{\Psi}_h \boldsymbol{\epsilon}_{t-h}. \tag{4}$$

where the weights $\boldsymbol{\Psi}_h$ are functions of the reduced-form coefficient matrix $\boldsymbol{\Pi}$. Given the invertibility assumption, I obtain the structural vector moving average representation

$$\boldsymbol{y}_t = \sum_{h=0}^{\infty} \boldsymbol{\Psi}_h \boldsymbol{A^{-1}} \boldsymbol{A}\, \boldsymbol{\varepsilon}_{t-h} = \sum_{h=0}^{\infty} \boldsymbol{\Theta}_h \boldsymbol{u}_{t-h}. \tag{5}$$

where $\boldsymbol{\Theta}_h = \boldsymbol{\Psi}_h \boldsymbol{A^{-1}}$ is the n x n matrix of structural responses to the vector of structural shocks that happened h periods before. Without loss of generality, I order the global supply chain shock as the first element (u_{1t}) of the vector of structural shocks $\boldsymbol{u}_t$; therefore, I aim to identify the first column of $\boldsymbol{A^{-1}}$, denoted by the vector $\boldsymbol{h}_1$.

Inference via External Instrument.— The identification strategy consists of using the stationary series of FEU price surcharges (Z_t) as external instrument. The instrument must be relevant

$$E[Z_t u_{1t}] = \alpha \neq 0 \tag{6}$$

and it must be exogenous to the other structural shocks

$$E[Z_t \boldsymbol{u}_{2:nt}] = \boldsymbol{0}. \tag{7}$$

Here $\boldsymbol{u}_{2:nt} = (u_{2t} \dots u_{nt})'$ is the $(n-1)$ x 1 vector of all the other structural shocks. Under the two conditions above and the invertibility assumption, the structural impact vector $\boldsymbol{h}_1$ is identified up to a constant of proportionality (Stock and Watson, 2016; Baumeister and Hamilton, 2024). I resolve the scale ambiguity by defining an increase in the structural shock u_{1t} as an event that raises the observed variable y_{1t} by δ units

$$\widetilde{\boldsymbol{h}}_1 = (E[Z_t \boldsymbol{\epsilon}_{2:nt}]/E[Z_t \epsilon_{1t}]) \;\times\; \delta \tag{8}$$

subject to $\boldsymbol{\Omega} = \boldsymbol{A^{-1}} \boldsymbol{D} (\boldsymbol{A^{-1}})'$. Thus, if $\widetilde{\boldsymbol{h}}_1$ is identified and the VAR is invertible, the structural shock u_{1t} and its variance d_{11}, and the forecast error variance decomposition are also

identified.

Estimation with COVID.— The inclusion of 2020 data poses substantial challenges when estimating the model. Following Lenza and Primiceri (2020), I conceptualize COVID as a regime in which the innovation variance of the VAR is scaled up, while the autoregressive dynamics are unchanged. Formally, I define a regime indicator $s_t \in \{1, 2\}$, where $s_t = 1$ denotes normal times and $s_t = 2$ denotes the COVID period. The autoregressive coefficients of the VAR are held constant across regimes, $\mathbf{\Pi}_1 = \mathbf{\Pi}_2 = \mathbf{\Pi}$, but there is a marked scale-up in the innovation variance, $\mathbf{\Omega}_2 = \kappa^2\, \mathbf{\Omega}_1$, which generates large outliers. To implement this, I adopt a feasible Generalized Least Squares (GLS) iterative estimation procedure as suggested in Hamilton (Forthcoming), where the observations in the COVID sample are downweighted by the scaling factor κ, which is in turn estimated via Maximum Likelihood Estimation

$$\kappa^2 = \frac{1}{T_2 k} \sum_{t=1}^{T} \left(\boldsymbol{y}_t - \mathbf{\Pi}\boldsymbol{x}_{t-1}\right)' \mathbf{\Omega}_1^{-1} \left(\boldsymbol{y}_t - \mathbf{\Pi}\boldsymbol{x}_{t-1}\right) \mathbb{1}\{s_t = 2\}. \tag{9}$$

Here T_2 is the total number of observations in the COVID regime, and k is the number of endogenous variables considered in the model. The same procedure is applied to the two-stage least squares estimation of the structural impact vector $\widetilde{\boldsymbol{h}}_1$. In the empirical analysis, I define the COVID regime as the period from January to December 2020.

3.2 Empirical Specification

The baseline specification of the empirical model employed in the analysis is a monthly VAR which comprises two global variables, the Global Supply Chain Pressure Index (GSCPI), ordered first as it serves as the instrumented variable, and the West Texas Intermediate (WTI) oil price, along with three US variables: Consumer Price Index (CPI), industrial production, and unemployment rate. The sample period begins in January 1998, with the start dates determined by the availability of the Global Supply Chain Pressure Index, which

is available no earlier than January 1998. The end of the sample is set at December 2024. However, the first-stage estimation is conducted over the shorter period from January 2014 to December 2024, as price announcement data from the three major shipping companies are unavailable before January 2014.

The variables in the model are transformed into logarithms multiplied by 100, with two exceptions: the Global Supply Chain Pressure Index, which is retained in its original units as standard deviations from the mean, and the unemployment rate, which is expressed as a percentage. The VAR includes 12 lags.

3.3 Propagation Mechanism

I now provide evidence of the propagation mechanism of a global supply chain shock identified via external instrument. Figure 3 shows the structural Impulse Response Functions (IRFs) of the baseline model, normalized to a structural shock that increases the GSCPI by 0.5 units, corresponding to a $1,340 price surcharge. This $1,340 price surcharge corresponds to the peak surcharge observed by the instrument in December 2020. To contextualize this magnitude, a back-of-the-envelope calculation relates the $1,340 surcharge to prevailing shipping costs. According to the Freightos Baltic Index, the average shipping cost for a FEU container in December 2020 was approximately $2,650 across major global routes. Thus, the $1,340 surcharge represents roughly 50% of the average shipping cost, providing a meaningful scale for evaluating the structural shock's magnitude. In all subsequent figures, the 68%, 80%, and 90% confidence bands are computed using 4,000 recursive wild bootstrap replications, in which the residuals are rescaled by independently drawn Rademacher random variables.

After the initial increase, the GSCPI reverses back and returns to its steady state after approximately three years. US consumer prices exhibit a sluggish and persistent increase, consistent with a price friction mechanism, and the response is highly statistically significant. In contrast, oil prices initially decline on impact and then gradually increase over

time; however, the response is not statistically significant at conventional levels. Turning to real economic effects, the supply chain shock induces an immediate decline in industrial production, which reaches its lowest point after two quarters before gradually recovering. This response is highly statistically significant and persistent, with industrial production returning to its steady state no earlier than three years post-shock. The unemployment rate rises immediately, peaks after one year, and then gradually declines toward its steady state, remaining elevated for three additional years. At the peak, a supply-chain shock associated with a \$1,340 price surcharge raises consumer prices by almost 0.4% and oil prices by 2.3%, while reducing industrial production by 0.9% and increasing unemployment by 0.16%.

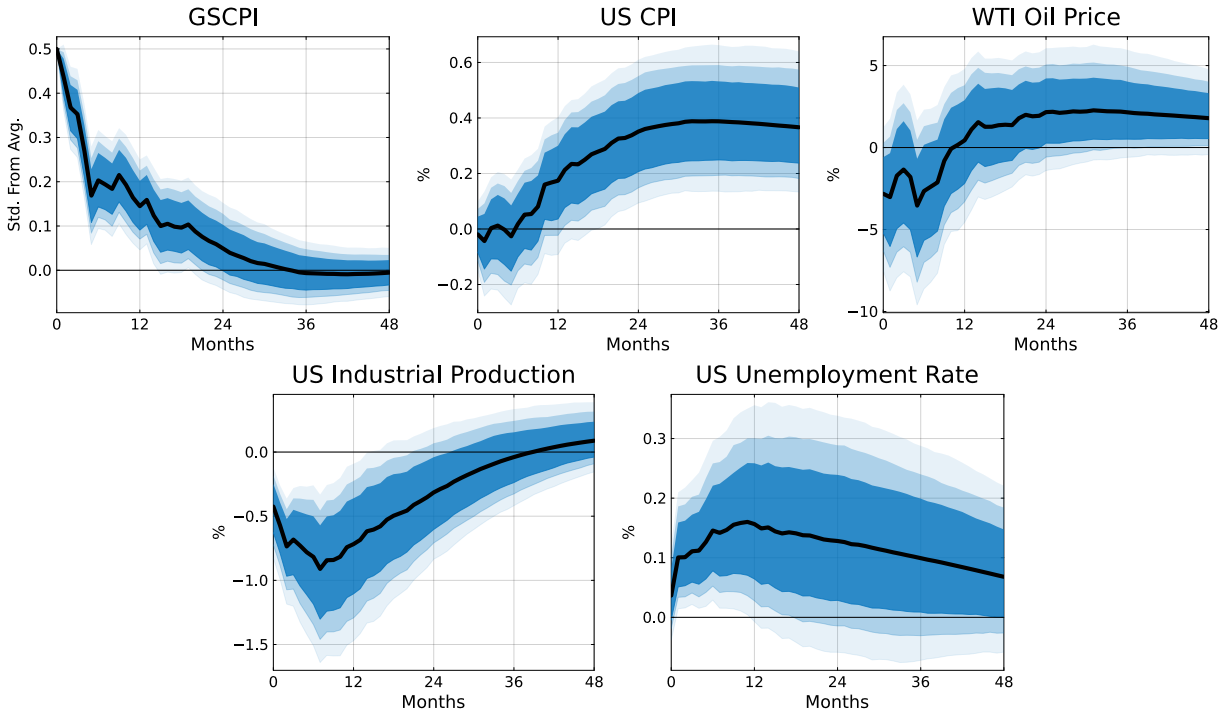


Figure 3: Structural Impulse Responses to a Global Supply Chain Shock.

Notes: Impulse responses to a global supply chain shock corresponding to a \$1,340 price surcharge. The solid line is the point estimate and the shaded areas are 68, 80 and 90 percent confidence bands, respectively. First stage sample from January 2014 to December 2024. OLS regression: F-statistic: 18.18, R^2: 12.88%, Adjusted R^2: 12.17%. Feasible GLS regression to down-weight COVID period: F-statistic: 12.54, R^2: 9.25%, Adjusted R^2: 8.51%.

Discussion.— At the aggregate level, a global supply chain shock functions as a cost-push shock in the New-Keynesian framework, raising firms' marginal costs due to higher trans-

portation costs and shortages of intermediate inputs of production. As profit margins decline, firms reduce production and cut back on labor demand, leading to higher unemployment. Finally, the consumer price level rises gradually, reflecting both the pass-through of elevated input costs and delays in the delivery of final goods to markets. The most pronounced effect at impact is on production, which declines by 0.5%. These findings align with the theoretical predictions of Alessandria et al. (2023), who suggest that, despite the shock's temporary nature, it takes time for the economy to recover. Bai et al. (2024) study the macroeconomic effects of global supply chain disruptions by employing sign restrictions on the comovements of output, prices, and spare capacity, derived from a model that incorporates search frictions between producers and retailers. Their analysis indicates only transitory real effects from an adverse global supply chain shock, with contractionary impacts on real GDP and unemployment lasting no more than two quarters. While they do report persistent price increases, these are less prolonged than those observed in my study and in Benigno et al. (2022).

3.4 Wider Effects

To gain a deeper understanding of the macroeconomic propagation of global supply chain shocks, I examine their effects across key components of the real economy and price dynamics. I analyze sectoral responses in industrial production across major subsectors, aggregate service sector activity and employment, and consumer prices disaggregated by CPI category. I estimate impulse response functions by incorporating each variable individually into the baseline model, maintaining the same sample period as in the baseline specification.

Industrial production.— Figure 4 presents the IRFs for eight key industrial sectors alongside the aggregate industrial production series. I examine the two primary components of industrial production by industry group, manufacturing and mining, as well as the major subcategories within manufacturing: durable and nondurable goods. Additionally, I focus on food and beverage and motor vehicles and parts, two sectors critical for business cycle

analysis and among the largest components of nondurable and durable goods, respectively. I also analyze materials and final products, the two main components of industrial production by market group. Final products are related to immediate pass-through to consumer prices, while materials, as intermediate inputs, capture persistent second-round effects on firms' marginal costs.

Following a global supply chain shock, all industrial production variables decline immediately, reach their trough within the first few quarters, and then recover to pre-shock levels between two and three years later. All impulse response functions are highly statistically significant, except for mining. This exception is unsurprising: despite US reliance on imported rare earth materials and other mining products, mining production has a localized supply chain, resulting in a response to global supply chain shocks that is not statistically different from zero. Manufacturing displays a sharper peak contraction than the aggregate index (1.32% vs. 0.9%). At their respective troughs, durable goods fall more than nondurables (1.44% vs. 0.77%), with total manufacturing lying in between. Motor vehicles and parts exhibit the largest peak decline (4.5%), while food and beverages show the smallest (0.45%), with a quick return to steady state. Among market groups, the peak response of materials (1.1%) exceeds that of final products (0.95%).

To interpret the heterogeneity in response magnitudes, I employ the look-through exposure metric developed by Baldwin, Freeman and Theodorakopoulos (2023). Constructed from the OECD's 2021 Inter-Country Input-Output (ICIO) tables, this metric measures the proportion of manufactured inputs sourced abroad by a US manufacturing sector relative to total inputs of production, accounting for suppliers' own suppliers.[2] Using this metric, I construct predicted impulse responses by rescaling the headline IRF proportionally to each sector's relative exposure:

$$\widetilde{\mathrm{IRF}}_i = \widehat{\mathrm{IRF}}_h \times \frac{\mathrm{LT}_i}{\mathrm{LT}_h}. \tag{10}$$

[2] Baldwin, Freeman and Theodorakopoulos (2023) compute look-through exposure for 17 NAICS 31–33 manufacturing subsectors. I calculate exposure for broader manufacturing aggregates and the two market group series, using weights from the Industrial Production and Capacity Utilization (G.17) statistical release by the Board of Governors of the Federal Reserve System.

Here, $\widehat{\text{IRF}}_h$ is the impulse response function of the headline series, and LT_i and LT_h represent the look-through exposure for sector i and the headline, respectively.

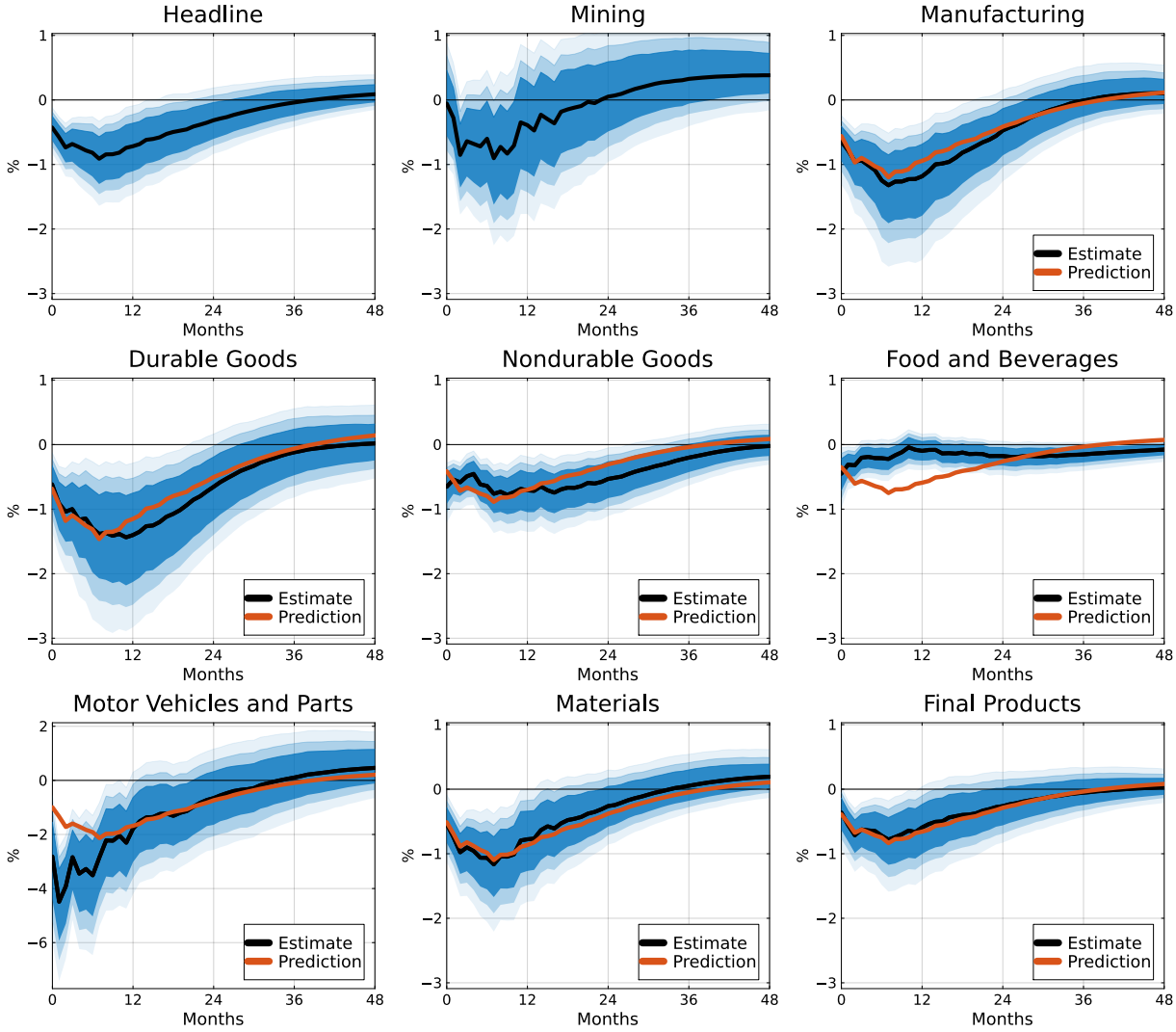


Figure 4: The Effects of Global Supply Chain Shock on US Industrial Productions.

Notes: Impulse responses to a global supply chain shock corresponding to a \$1,340 price surcharge. The solid black line is the point estimate and the shaded areas are 68, 80 and 90 percent confidence bands, respectively. The orange line is the predicted sectoral IRF, derived by rescaling the headline industrial production IRF with the ratio of sectoral to headline look-through exposure measures. All subplots share the same y-axis scale, except for Motor Vehicles and Parts.

These predicted responses, shown as orange lines in Figure 4, closely match the estimated sectoral IRFs, affirming the role of the exposure to the global supply chain as a sufficient statistic to explain sectoral dynamics. Manufacturing, with a look-through exposure of

12.3%, is more exposed than the aggregate index, explaining its larger response. Durable goods are more exposed (15%) than nondurables (9.1%), and the total manufacturing response falls between the two, reflecting its weighted average composition. Motor vehicles and parts, with the highest exposure (21.9%), exhibit the most severe contraction, while food and beverages, with the lowest exposure (7.7%), experience the mildest. For food and beverages, the predicted IRF captures the response well on impact but overstates its persistence. This muted and short-lived response reflects the sector's limited reliance on foreign inputs and the prevalent use of capital goods that operate over multiple production cycles. Lastly, the different exposure of materials (11.3%) and final products (8.6%) explains the difference in their responses.

Services.— To assess the broader macroeconomic reach of global supply chain shocks, I examine their impact on the non-tradable sector, specifically services. Figure 5 presents the impulse responses of the ISM Services Activity Index, ISM Services Employment Index, and ISM Manufacturing Production Index to a global supply chain shock corresponding to a $1,340 price surcharge. Both services indicators exhibit no statistically significant response on impact, consistent with the fact that services are not directly exposed to global supply chain disruptions. However, approximately two quarters after the shock, both measures display a significant contraction, which gradually fades, returning to pre-shock levels within a year.

The inclusion of the ISM Manufacturing Production Index enables a meaningful structural comparison across tradable and non-tradable sectors, as all three indicators are survey-based and measured on comparable qualitative scales. The production index exhibits a sharp and immediate drop, capturing the direct effect of global supply chain shocks on the tradable goods sector. In contrast, the services activity index shows a delayed and smaller contraction, reflecting the presence of spillover effects rather than direct exposure. This dynamic, initial inertia followed by a transitory decline, suggests that disruptions in the production sector

generate broader macroeconomic slack, which gradually propagates into the non-tradable sector. As conditions deteriorate, service firms adjust activity and employment accordingly. Because these effects are indirect, the response of the services sector is both lagged and more muted relative to that of the production sector.

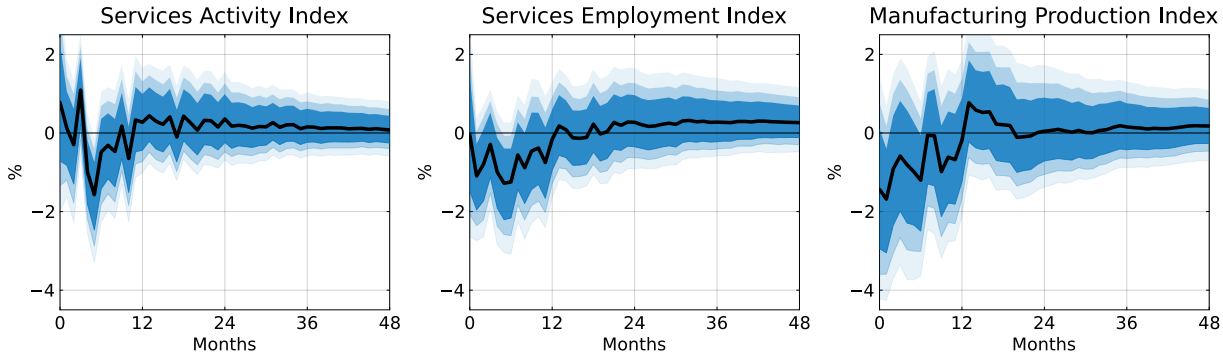


Figure 5: The Effects of Global Supply Chain Shock on Non-Tradable Sector.

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. The solid black line is the point estimate and the shaded areas are 68, 80 and 90 percent confidence bands, respectively. All subplots share the same y-axis scale.

Consumer prices.— Figure 6 shows the responses of different components of CPI, including core, services, durable and nondurable goods, food and beverages, new vehicles, housing, and medical care, together with the headline response from the baseline model. A consistent pattern emerges across all components: each category exhibits a sluggish and persistent increase, with many remaining elevated even four years after the shock. This broad-based inflationary response reflects a gradual transmission from production disruptions to consumer prices, consistent with the presence of nominal rigidities.

The core CPI response is nearly identical to the headline CPI, reflecting the broad-based nature of the inflationary impact. This close alignment is consistent with the widespread decline observed across core production sectors.

The services CPI component exhibits a relatively mild yet persistent increase in response to a global supply chain shock. This inflationary pattern aligns with the observed declines in service sector activity and employment documented in Figure 5. Given that services are only indirectly exposed to global supply chain disruptions, the associated contraction in output is

more limited. Accordingly, the pass-through to consumer prices is less pronounced, though still persistent.

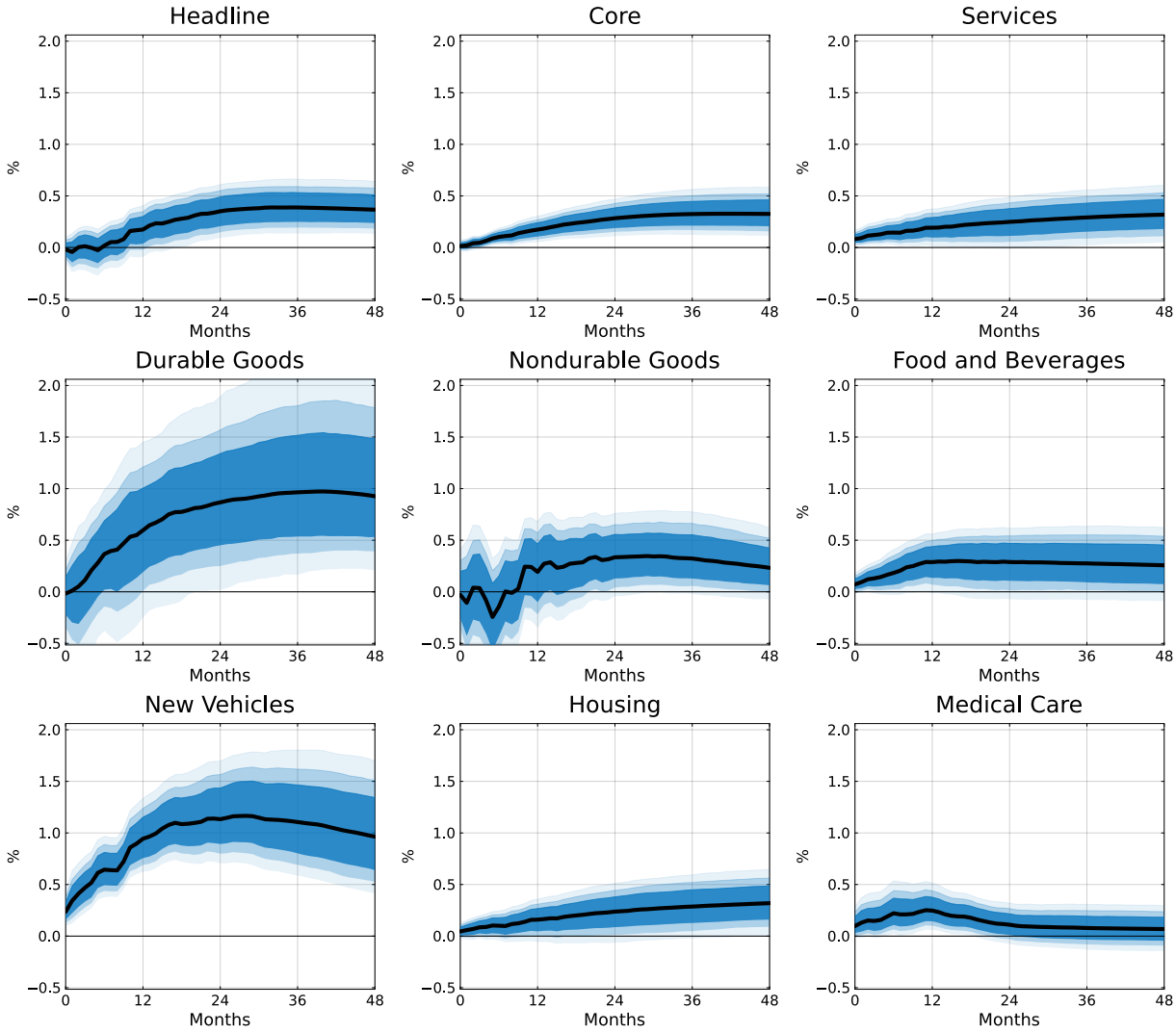


Figure 6: The Effects of Global Supply Chain Shock on US Consumer Prices.

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. The solid black line is the point estimate and the shaded areas are 68, 80 and 90 percent confidence bands, respectively. All subplots share the same y-axis scale.

Durable and nondurable goods exhibit markedly different inflationary responses, mirroring their respective production dynamics shown in Figure 4. Durables, which are more exposed to global supply chains, experience a stronger and more persistent price increase. This parallels the sharper and more prolonged contraction in durable manufacturing, partic-

ularly in sectors such as motor vehicles and parts. Nondurables, with lower exposure, exhibit a more modest price increase.

The divergence is even more pronounced when comparing food and beverages to new vehicles. The food and beverage category, which shows the smallest production response due to its localized supply chain structure, also displays the mildest CPI increase. By contrast, new vehicles, embedded in a highly globalized and input-intensive supply chain, exhibit the largest and most persistent CPI response, closely tracking the steep and extended production decline in motor vehicles and parts.

Lastly, I include housing and medical care to illustrate how sectors that appear largely insulated from international trade can still be affected by global supply chain disruptions. In addition, housing is the largest component of the CPI basket, making its inflationary dynamics particularly interesting. Both categories show persistent price increases following the shock, underscoring the economy-wide reach of supply chain disruptions, even in sectors not traditionally viewed as integrated in the global supply chain.

Discussion.— Sectoral responses to a global supply chain shock exhibit similar qualitative dynamics but vary significantly in magnitude. Among production sectors, this heterogeneity is strongly correlated with each sector's degree of exposure to the global supply chain. Predicted impulse response functions, obtained by rescaling the IRF of aggregate industrial production by relative look-through exposures, closely match the estimated sectoral dynamics. This suggests that look-through exposure serves as a sufficient statistic for explaining cross-sectoral variation. Sectors experiencing the most pronounced output contractions, such as durable manufacturing, and in particular motor vehicles, also exhibit the strongest pass-through to consumer prices. While all CPI components respond persistently to the shock, durable goods and new vehicles stand out in both the size and persistence of their inflationary dynamics.

Beyond the tradable goods sectors, I find that global supply chain shocks spill over

into non-tradable services. Although the responses of service activity and employment are more modest and transitory, they confirm the broader macroeconomic reach of these shocks. Services CPI also rises persistently, reflecting higher operational costs that are gradually passed on to consumers despite the sector's lower direct exposure to the global supply chain.

These findings underscore what makes global supply chain shocks distinct from other well-studied supply-side shocks, such as oil supply and oil price shocks. Whereas oil shocks generate highly heterogeneous production effects (Tenreyro, 2022; De Santis, 2024), driven by sector-specific energy intensity and substitution elasticities, global supply chain disruptions cause widespread declines due to the physical unavailability of intermediate inputs. These shortages are difficult to hedge and, unlike oil supply shocks, cannot be offset through government-backed insurance mechanisms such as the Strategic Petroleum Reserve or coordinated responses via the International Energy Agency. As a result, global supply chain shocks produce a broader and more synchronized contraction across sectors, accompanied by persistent inflationary pressures even in categories traditionally seen as insulated. This highlights the structural vulnerability of globally integrated production systems and the need for differentiated macroeconomic policy responses.

4 Global Supply Chain Shocks and The COVID Era

The causes of the pandemic-era inflation have sparked intense debate in the literature, with competing explanations emphasizing either demand- or supply-side factors. While global supply chain shocks have been increasingly acknowledged as a contributing factor, all existing analyses rely on sign-restricted or narrative sign-restricted SVARs to assess their contribution to the pandemic-era inflation and economic recovery. In this section, I contribute to the literature by providing a comprehensive analysis of the cumulative historical contribution of global supply chain shocks to the rise of consumer prices and the recovery of industrial production from January 2020 to December 2024, by leveraging the instrument and structural

framework developed in Sections 2 and 3. In particular, I will answer two key questions: how significantly global supply chain shocks contributed to post-pandemic inflation and how these shocks influenced the recovery of economic activity.

4.1 Historical Decomposition

Given the econometric framework outlined in Section 3, if the structural impact vector $\widetilde{\boldsymbol{h}}_1$ is identified, Hamilton (Forthcoming) shows that the value of the first structural shock at date t, u_{1t}, can be recovered from the vector of the reduced-form innovations $\boldsymbol{\epsilon}_t$ as follows

$$u_{1t} = \left(\widetilde{\boldsymbol{h}}_1' \boldsymbol{\Omega}^{-1} / \, \widetilde{\boldsymbol{h}}_1' \boldsymbol{\Omega}^{-1} \widetilde{\boldsymbol{h}}_1 \right) \boldsymbol{\epsilon}_t \, . \tag{11}$$

Using the identified structural shock, I can estimate the contribution of the series of global supply chain shocks to the historical values of the variables included in the VAR model. The structural moving average representation from equation (5) implies:

$$\boldsymbol{y}_t(u_1) = \sum_{h=0}^{\infty} \boldsymbol{\Psi}_h \widetilde{\boldsymbol{h}}_1 u_{1t-h} \, . \tag{12}$$

Here, $\boldsymbol{y}_t(u_1)$ is referred to as historical decomposition, obtained as the infinite sum of the impulse responses to the global supply chain shock u_{1t-h} at each forecast horizon h, weighted by the corresponding structural impulse response coefficients $\boldsymbol{\Psi}_h \widetilde{\boldsymbol{h}}_1$.

4.2 Post-Pandemic Inflation

Figure 7 shows the cumulative historical contribution of global supply chain shocks to consumer prices from January 2020 to December 2024, measured in percentage deviations from the January 2020 level. The figure reveals that global supply chain shocks were key drivers of post-pandemic inflation, particularly during the first half of the sample period.

Beginning in the second half of 2020, severe disruptions at major hubs, such as the

ports of Los Angeles and Long Beach (handling a combined 8.6 million FEUs annually), emerged alongside chokepoint disruptions in the Red Sea and Gulf of Aden due to the Houthi conflict. The delayed pass-through of these shocks triggered significant price increases in early 2021. The impact intensified through 2021 and 2022, exacerbated by global supply chain shocks associated with events such as the partial closure of China's Yantian port in Shenzhen (7 million FEUs annually, ranking 4th globally) from May to June 2021, and the shutdown of the Meishan terminal at Ningbo-Zhoushan port (16.3 million FEUs annually, 3rd globally) in August 2021, disrupting 25% of its container cargo capacity. The March 2021 Suez Canal obstruction, blocking a chokepoint responsible for 12% of global trade, further strained the system. In early 2022, stringent lockdown measures in Shenzhen and Shanghai, which impacted Yantian and Shanghai ports (the world's busiest, handling 21.8 million FEUs annually), and the Russian invasion of Ukraine, which disrupted Black Sea trade, led to the peak contribution to consumer prices observed in early 2023. Although the impact began to subside thereafter, new disruptions persisted into 2024, notably the January suspension of Red Sea transit, which forced rerouting via the Cape of Good Hope and prolonged inflationary pressures.

This trajectory highlights the critical role of global supply chain shocks in driving consumer price inflation during this period. In 2021, they accounted for an average of 51% of the surge in consumer prices, reflecting the scale of the unprecedented disruptions worldwide. My findings confirm the primary role of global supply chain shocks in shaping the early post-pandemic inflation dynamics found by Bai et al. (2024). The remaining variation could be largely attributable to demand factors and the substantial fiscal deficit, as noted by Hazell and Hobler (2024), Jordà and Nechio (2023), Giannone and Primiceri (2024), and Bergholt et al. (2024). In 2022, the influence of global supply chain shocks diminished, explaining approximately 32% of the consumer price increase on average. This aligns with findings from Goda and Soltas (2022), Hobijn and Sahin (2022), and Lee, Park and Shin (2023), who demonstrate that adverse shocks to productive capacity sustained elevated inflation levels

from 2022. In the subsequent years, the contribution of global supply chain shocks to inflation moderated while remaining significant, at 30% in 2023 and 22% in 2024. Overall, my findings suggest that global supply chain shocks had a more substantial and persistent impact on consumer prices throughout the pandemic recovery than previously recognized.

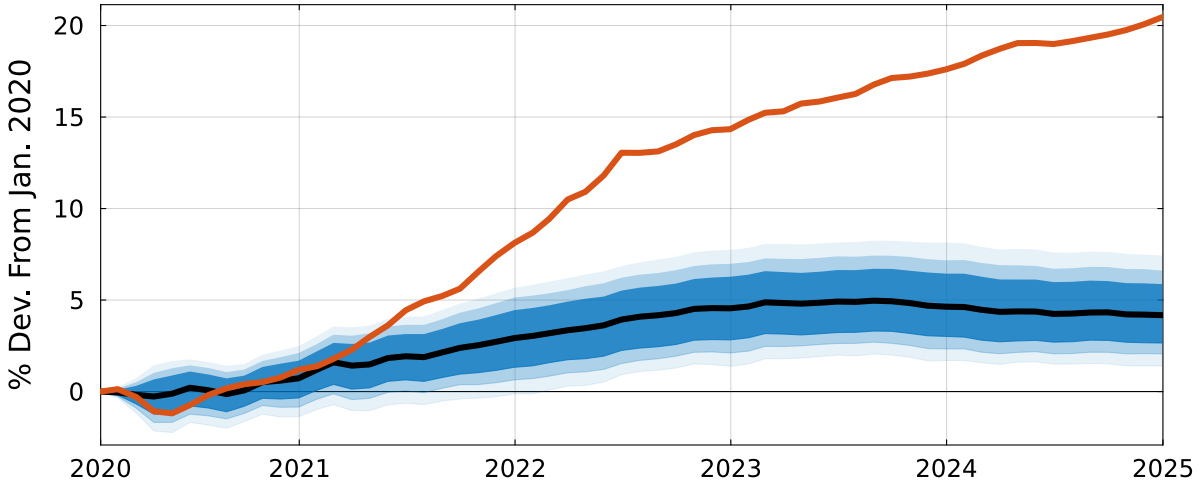


Figure 7: Historical Decomposition of Consumer Prices

Notes: The figure illustrates the historical contribution of global supply chain shocks to the US CPI, expressed as a percentage deviation from the pre-pandemic level (January 2020). The solid orange line is the actual series, the solid black line is the point estimates, and the shaded areas are 68, 80 and 90 percent confidence bands, respectively.

4.3 Recovery of Industrial Production

Figure 8 shows the cumulative historical contribution of global supply chain shocks to industrial production for the period January 2020 - December 2024, measured in percentage deviations from production level observed in January 2020. The figure highlights the substantial downward pressure these shocks exerted on the economic recovery. By November 2021, industrial production had returned to its pre-COVID level, but in a counterfactual scenario with only global supply chain shocks, recovery would have been delayed until at least May 2023.

From January 2020, following reports of the COVID-19 outbreak in China, major shipping companies implemented extraordinary blank sailing omissions on key trade routes,

notably on the Trans-Pacific and East-West corridors. By February 2020, severe disruptions in Chinese ports, as reported by MSC, led to critical shortages of refrigerated container plugs and prevented vessels from discharging at designated ports. These disruptions were compounded by strict COVID-19 containment measures, such as port controls, labor restrictions, and travel bans, which led to significant delays in the shipment of intermediate goods and sharply increased production costs.

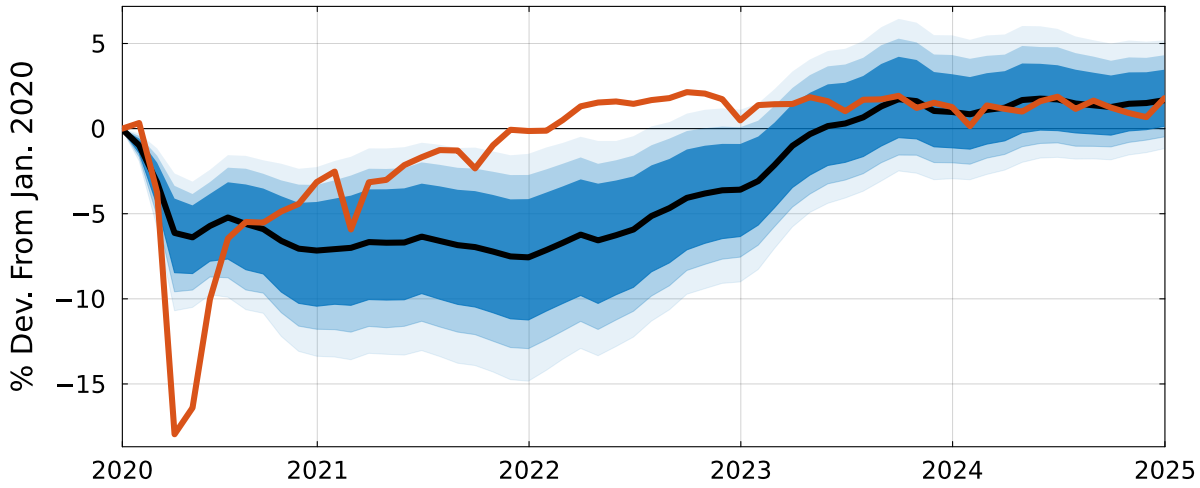


Figure 8: Historical Decomposition of Industrial Production

Notes: The figures show the historical contribution of global supply chain shocks to the US Industrial Production in percentage deviation from the pre-pandemic level (January 2020). The solid orange line is the actual series, the solid black line is the point estimates, and the shaded areas are 68, 80 and 90 percent confidence bands, respectively.

In April 2020, global supply chain shocks caused a nearly 6% decline in industrial production, contributing to 34% of the total decrease. Although Industrial production began to recover in the second half of 2020, downward pressures from supply chain shocks intensified. The contribution of supply chain shocks to the production shortfall peaked in November 2021 at -7.5%. Their effect gradually declined thereafter, with the negative contribution dissipating by May 2023.

While most existing studies have emphasized the nominal and inflationary effects of supply disruptions, my findings highlight their significant and persistent impact on real economic activity.

4.4 Summary

The historical decomposition analysis reveals that global supply chain shocks played a more prominent role in the early phase of post-pandemic inflation than previously recognized. My findings confirm the central importance of these shocks in shaping inflation dynamics in 2021, consistent with the evidence presented by Bai et al. (2024). However, I do not dismiss the role of demand-side forces. As highlighted by Hazell and Hobler (2024), Jordà and Nechio (2023), Giannone and Primiceri (2024), and Bergholt et al. (2024), large-scale fiscal stimulus and pent-up demand also contributed meaningfully to the inflationary surge. In particular, beginning in the second half of 2021, other shocks increasingly became the dominant drivers of the price level, consistent with the timing of the massive fiscal recovery plan.

When viewed alongside the dynamics of industrial production, these results suggest that the fiscal response to the pandemic supported a faster recovery of real activity, advancing the timeline of production returning to pre-pandemic levels by roughly 18 months relative to a scenario with only global supply chain shocks. However, this recovery came at the cost of higher inflation, underscoring the trade-off between supporting output and anchoring prices during supply-side disturbances.

Finally, this analysis contributes a novel insight to the ongoing policy debate: while much of the discussion on global supply chain shocks has centered on their inflationary consequences (Tenreyro, 2021; Lane, 2022; Guerrieri et al., 2023), my findings show that these shocks also have long-lasting contractionary effects on real activity. This persistence highlights the importance of recognizing global supply chain disruptions not only as a source of persistent inflation but also as a meaningful driver of output fluctuations over the business cycle.

5 Quantitative Importance

Forecast Error Variance Decomposition.— The preceding analysis has shown that global supply chain shocks are not only a source of persistent inflation but also a meaningful driver of output fluctuations over the business cycle. Building on this insight, I now turn to a formal quantification of their contribution to macroeconomic volatility. Specifically, I assess the average importance of global supply chain shocks in explaining forecast error variance across key aggregate variables in the baseline model. This allows me to evaluate how much of the business cycle is systematically accounted for by these shocks over different time horizons.

Under the identification assumptions of Section 3, if the structural impact vector $\widetilde{\boldsymbol{h}}_1$ is identified, the variance of the shock is also identified as

$$d_{11} = \widetilde{\boldsymbol{h}}_1' \boldsymbol{\Omega}^{-1} \widetilde{\boldsymbol{h}}_1 \tag{13}$$

where $\boldsymbol{\Omega}$ is the reduced-form variance-covariance matrix. Consequently, I compute the contribution of the global supply chain shock to the h-step-ahead forecast error variance-covariance matrix of $\boldsymbol{y}_t$ as

$$\sum_{s=0}^{h-1} \boldsymbol{\Psi}_h \widetilde{\boldsymbol{h}}_1 d_{11} \widetilde{\boldsymbol{h}}_1' \boldsymbol{\Psi}_h'. \tag{14}$$

The ratio of the diagonal elements of (14) to those of the diagonal elements of the overall h-step-ahead forecast error variance-covariance matrix, $\sum_{s=0}^{h-1} \boldsymbol{\Psi}_h \boldsymbol{\Omega} \boldsymbol{\Psi}_h'$, provides the percentage of the h-step-ahead variances of $\boldsymbol{y}_t$ accounted by the first structural shock.

Discussion.— Table 1 presents the results. The global supply chain shock accounts for the vast majority of fluctuations in the global supply chain pressure index, explaining almost 80% of its variance on impact and nearly 60% in the long run. In contrast, the shock contributes minimally to oil price variability, with almost none of the short-term variation attributed

Table 1: Forecast Error Variance Decomposition

	US CPI	WTI Oil Price	US Ind. Prod.	US Unemp.	GSCPI
Horizon					
0	0.00	0.04	0.16	0.01	0.79
	[0.00, 0.10]	[0.02, 0.19]	[0.01, 0.40]	[0.00, 0.11]	[0.53, 0.97]
12	0.02	0.03	0.25	0.12	0.74
	[0.00, 0.19]	[0.00, 0.17]	[0.05, 0.54]	[0.01, 0.35]	[0.48, 0.93]
24	0.12	0.03	0.24	0.10	0.66
	[0.01, 0.39]	[0.00, 0.18]	[0.06, 0.53]	[0.00, 0.36]	[0.46, 0.84]
36	0.23	0.05	0.24	0.10	0.60
	[0.07, 0.53]	[0.00, 0.20]	[0.06, 0.53]	[0.00, 0.37]	[0.41, 0.78]
48	0.29	0.06	0.24	0.10	0.59
	[0.10, 0.60]	[0.00, 0.22]	[0.06, 0.52]	[0.00, 0.38]	[0.41, 0.77]
∞	0.35	0.07	0.24	0.09	0.58
	[0.12, 0.74]	[0.00, 0.25]	[0.08, 0.50]	[0.00, 0.35]	[0.40, 0.77]

Notes: The table shows the proportion of the forecast error variance of the variables in the baseline model explained by global supply chain shocks at horizons 0, 12, 24, 36, 48 months and in the long-run. The 90 percent confidence intervals are displayed in brackets.

to global supply chain disruptions, confirming that oil prices are largely disconnected from such shocks. The shock's contribution to consumer price fluctuations is small in the first year but grows over the long term, accounting for 35% of CPI variability in the long run. Turning to real variables, the global supply chain shock plays a significant role in driving real business cycle fluctuations. It explains a substantial portion of industrial production variability, increasing from 16% on impact to almost 25% in the long run. The shock's contribution is modest for unemployment on impact, but becomes relevant after one year.

Compared to the estimates of Bai et al. (2024), my findings attribute a larger share of long-run consumer price variability to global supply chain shocks, 35% versus their approximately 25% for personal consumption expenditure prices, while indicating a more gradual transmission on impact. More notably, my estimates imply a large role for global supply

chain shocks in driving real activity. Bai et al. (2024) find a limited contribution to real GDP variance, while my results for industrial production suggest nearly double the explanatory power. Taken together with the impulse response and historical decomposition analysis, these results confirm that global supply chain shocks are not only a source of persistent inflationary pressures but also key contributors to business cycle fluctuations.

6 Sensitivity Analysis

In this section, I present a series of robustness checks to assess the stability of the main results. Specifically, I examine the sensitivity of the estimates to alternative specifications of the instrument by sequentially excluding individual categories of disruptions. I also revisit the invertibility assumption and explore alternative empirical strategies for identifying global supply chain shocks. Additional robustness checks related to control variables and lag length are provided in the online Appendix A.

6.1 Testing the Role of Individual Disruption Categories

The instrument is constructed from price surcharges associated with distinct types of exogenous supply-side disruptions: operational issues, armed conflict, labor strikes, and extreme weather or natural disasters. A key robustness check involves assessing whether the results are disproportionately driven by specific episodes or by particular types of disruptions.

Figure 9 displays the aggregate-level results obtained by sequentially excluding one category of disruptions at a time (column by column) from the instrument. The findings remain remarkably consistent with the baseline specification presented in Section 3, effectively ruling out the possibility that the results are driven by any single category of disruptions. Excluding the operational disruptions serves as the most stringent robustness check for two reasons. First, events classified under this category are more prone to be contaminated by other contemporaneous shocks compared to strikes, natural disasters, or conflict-related

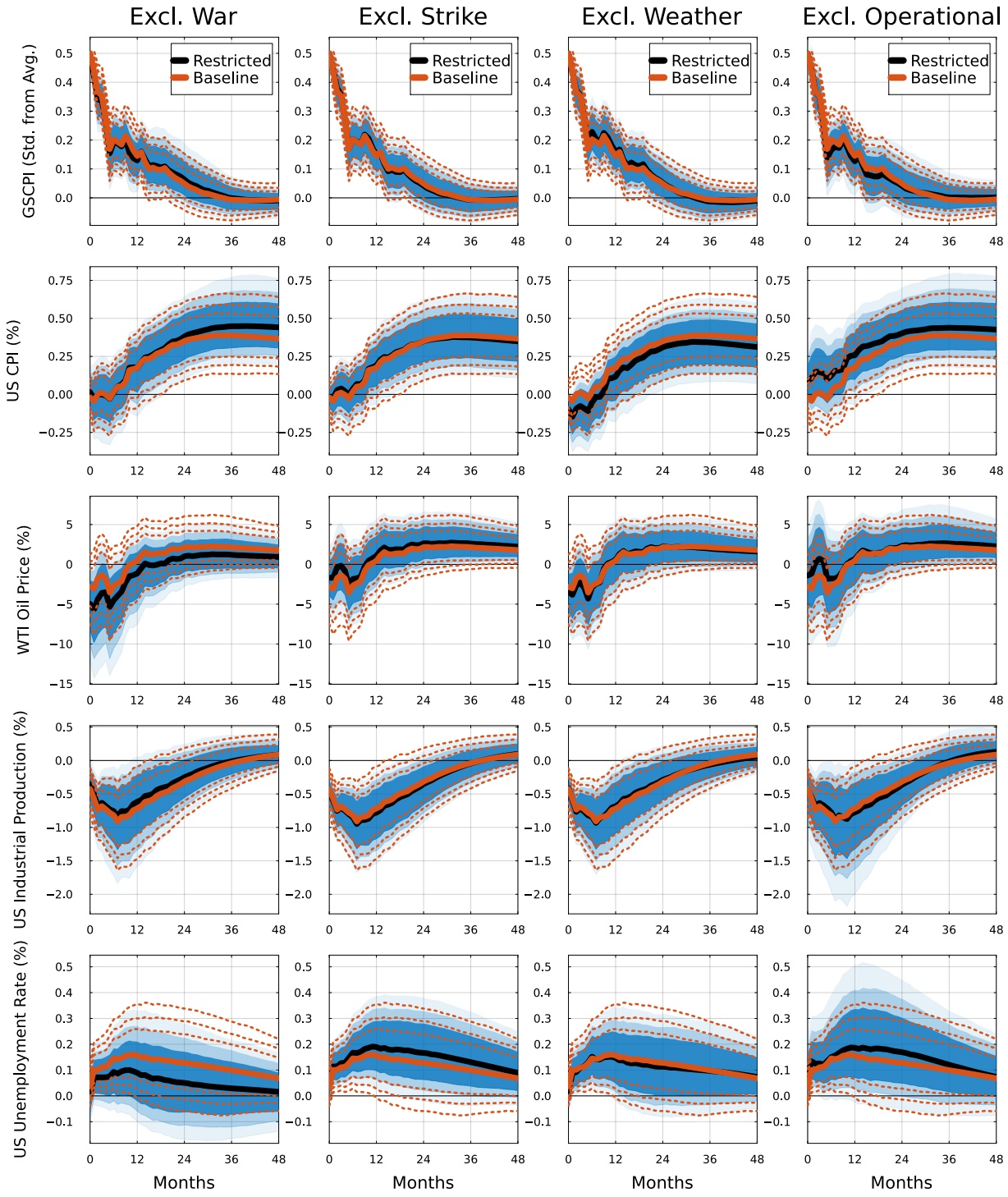


Figure 9: Robustness to Excluding Categories of Supply Chain Disruptions

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. Each column shows estimates excluding one category of surcharges (war, strike, climate, or operational) from the instrument. The orange lines represent the baseline specification, while the black lines represent the restricted estimates excluding the specified category. The solid lines represent the point estimates, and the shaded areas (and dotted lines) denote 68, 80, and 90 percent confidence bands, respectively.

disruptions. Second, operational disruptions account for nearly 53% of all individual disruptions in the sample, making them quantitatively dominant. The stability of results even after their exclusion provides strong support for the robustness of the identification strategy.

Another key robustness check involves excluding all disruptions directly or indirectly related to the COVID-19 pandemic, given the exceptional nature of the COVID shock relative to standard macroeconomic shocks. Of the 62 identified exogenous supply chain disruptions, 14 are congestion events driven by pandemic-induced labor shortages, logistics and operational difficulties, or the implementation of additional sanitary protocols; one corresponds to a COVID-19 outbreak that led to the partial shutdown of the Ningbo port in China; and one reflects a strike in Northern Europe stemming from deteriorated labor conditions due to the pandemic. These 16 disruptions are excluded from the instrument to test whether pandemic-specific events disproportionately influence the baseline results.

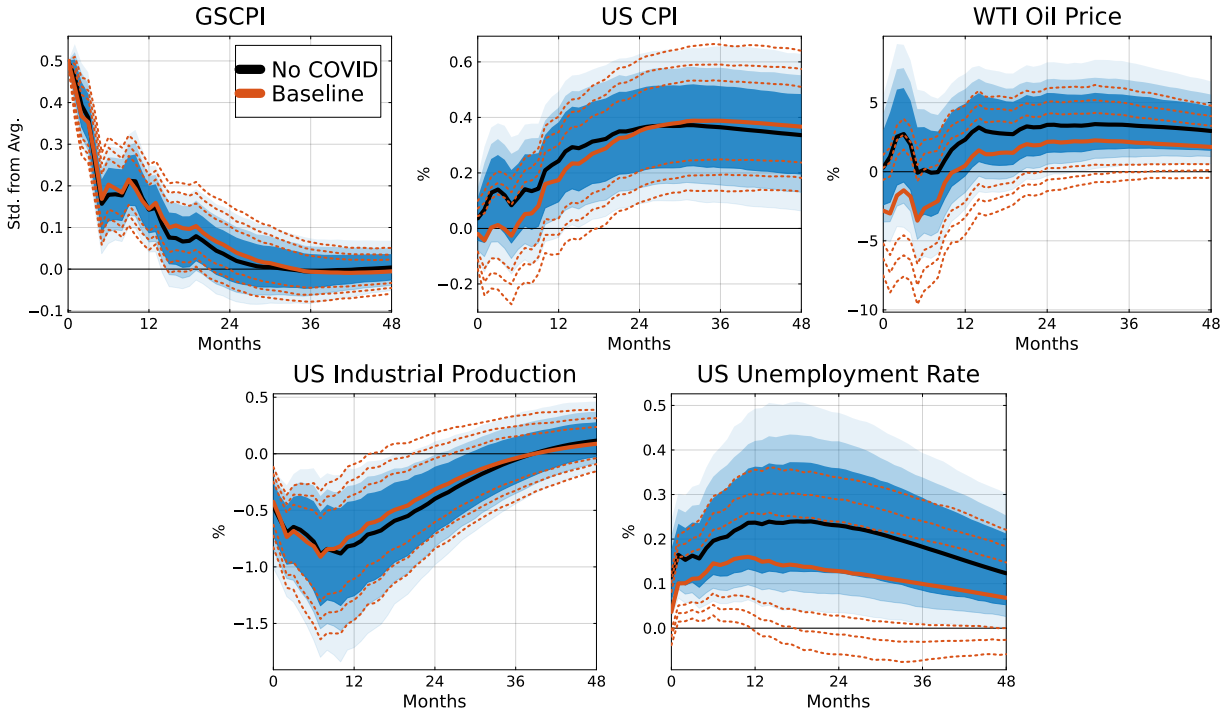


Figure 10: Robustness to Excluding COVID-Related Disruptions

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. The orange lines represent the baseline specification, while the black lines represent the restricted estimates excluding the COVID-related disruptions. The solid lines represent the point estimates, and the shaded areas (and dotted lines) denote 68, 80, and 90 percent confidence bands, respectively.

As shown in Figure 10, the baseline results remain robust to the exclusion of COVID-related disruptions. The pass-through to consumer prices appears somewhat faster, while the effects on unemployment are stronger and more persistent. The responses of industrial production and the GSCPI remain virtually unchanged, and WTI oil price continues to exhibit no statistically significant response.

6.2 Invertibility Assumption

The identification strategy relies on the highly restrictive assumption of invertibility, meaning that the structural shocks at each time horizon lie within the linear span of current and lagged values of the endogenous variables. Fortunately, Plagborg-Møller and Wolf (2022) note that the invertibility assumption can be tested by assessing whether lagged values of the instrument contain predictive information for the current value of the endogenous variables beyond that provided by their own lags. I conduct a series of F-tests and find that the coefficients of the lagged instruments are statistically indistinguishable from zero across all endogenous variables in the baseline VAR model and for various lag lengths of the instrument, thereby failing to reject the null hypothesis of invertibility. In addition, I perform a joint test of the null hypothesis that all coefficients on past realizations of the instrument are jointly zero, following the procedure in Hamilton (Forthcoming), and again fail to reject the invertibility assumption (see online Appendix A). This finding is consistent with the nature of the identified shock. Unlike news shocks, which Ramey (2016) and Nakamura and Steinsson (2018) argue are a common source of invertibility violations, the global supply chain shock does not present the foresight problem. Furthermore, by construction, the GSCPI captures comprehensive information on global disruptions, reducing the likelihood of omitted information that might otherwise compromise invertibility.

Given that the data do not reject invertibility, there is no need to rely on the internal instrument approach proposed by Plagborg-Møller and Wolf (2022), which relaxes this assumption by requiring the instrument to be orthogonal to structural shocks at all leads and

lags. In addition, the internal instrument approach is infeasible in my context because it requires the instrument to be observed over the full sample period in order to be ordered first in the VAR. Since the FEU price surcharge series has a shorter time span than the other VAR variables, I instead adopt the Proxy-SVAR framework, which flexibly accommodates instruments with limited history by separating the identification and estimation samples.

6.3 Local Projection - Instrumental Variable

Beyond the standard relevance and exogeneity conditions and the invertibility assumption, the consistency of structural impulse response functions also relies on the VAR model adequately capturing the covariance structure of the data. In a VAR(p) model, long-run responses are extrapolated from the first p sample autocovariances, which may lead to biased estimates if the lag length is misspecified (Montiel Olea et al., 2025). An alternative approach is to estimate dynamic causal effects using local projections, which are less sensitive to model misspecification and do not impose a specific dynamic structure. However, the local projection–instrumental variable (LP-IV) approach poses challenges in this setting due to the short sample of the external instrument. Estimating a separate IV regression at each horizon reduces the effective sample size, particularly at longer horizons, resulting in a substantial loss of statistical power.

To address this, I implement a battery of LP-IV regressions à la Jordà (2005) using the global supply chain shock identified from the Proxy-SVAR as the regressor of interest:

$$\boldsymbol{y}_{t+h} = \boldsymbol{\Theta}_{h,1}\hat{u}_{1t} + \boldsymbol{\Pi}\boldsymbol{x}_{t-1} + \boldsymbol{\eta}_{t+h} \ . \tag{15}$$

Here, $\boldsymbol{y}_{t+h}$ denotes the vector of outcome variables at horizon h, $\hat{u}_{1t}$ is the identified global supply chain shock, and $\boldsymbol{x}_{t-1}$ is a vector of controls, including twelve lags of the outcome variables. Using $\hat{u}_{1t}$ instead of the FEU price surcharge series overcomes the power limitations of the LP-IV framework, as it is available over the full sample starting in 1998.

Figure 11 compares the IRFs obtained from the Proxy-SVAR and LP-IV approaches. The responses are remarkably similar across both short and long horizons, providing evidence that the baseline VAR captures the underlying covariance structure of the data. As expected, the local projections are more erratic, as no dynamic restrictions are imposed across impulse horizons.

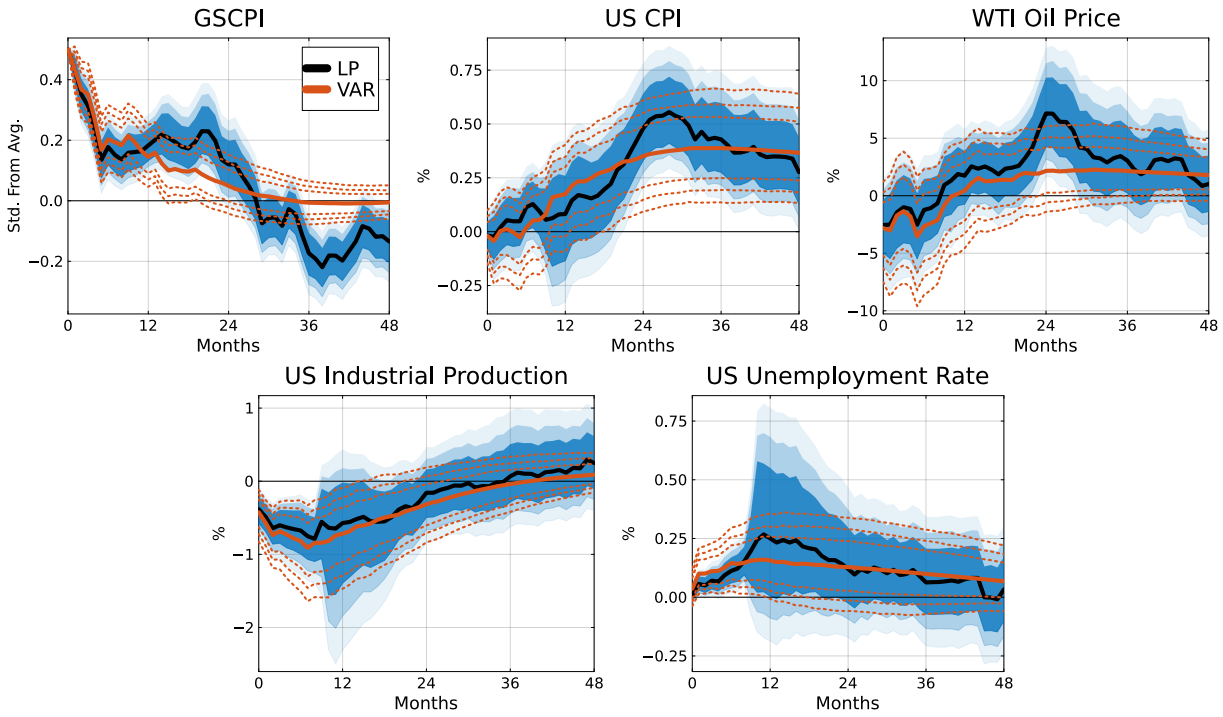


Figure 11: Proxy-SVAR vs. Local Projection Responses

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. The orange lines represent the baseline Proxy-SVAR results, while the black lines represent the LP-IV results. The solid lines represent the point estimates, and the shaded areas (and dotted lines) denote 68, 80, and 90 percent confidence bands, respectively.

7 Conclusion

This paper presents a novel identification strategy to assess the impact of global supply chain shocks on the macroeconomy. I identify 62 exogenous disruptions worldwide, derived from a narrative analysis of almost 7,000 price and surcharge updates from the three largest container shipping companies. These shocks have significant effects on the macroeconomy

and act as cost-push factors, raising prices persistently and exerting long-lasting downward pressure on economic activity.

I show that these shocks produce a broad-based contraction across all major production sectors and trigger persistent increases in consumer prices across nearly all major CPI subcategories. The magnitude of these effects varies systematically with each sector's exposure to the global supply chain, measured by the percentage of production inputs outsourced abroad. I demonstrate that sectors with higher exposure experience sharper output contractions and stronger price pass-through. Beyond the tradable goods sector, I find that global supply chain shocks spill over into non-tradable services. Although the response of service activity and employment is more modest and transitory, it highlights the wider macroeconomic reach of the global supply chain shocks.

I show that global supply chain shocks were the dominant drivers of inflation in the early stages of the post-pandemic period, accounting for an average of 51% of the increase in consumer prices in 2021. This contribution diminished over time but remained significant in 2022 (32%), 2023 (30%), and 2024 (22%). I also find that these shocks imposed a substantial drag on economic recovery. In a counterfactual scenario with only global supply chain shocks, industrial production would have returned to pre-pandemic levels 18 months later than it did. This highlights a trade-off: the fiscal stimulus of late 2021 accelerated the recovery but at the cost of higher inflation. I further demonstrate that global supply chain shocks are significant drivers of business cycle fluctuations, accounting for approximately 25% of the long-run variance in industrial production and 35% of the variance in consumer prices, thereby positioning them as key contributors to business cycle fluctuations.

I found that these results are robust across a wide range of empirical specifications, including alternative identification schemes, identification assumptions, and different specifications of the instrument. My identification strategy, centered on shipping company surcharges, offers a credible way to isolate exogenous supply-side disruptions.

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Online Appendix

The Macroeconomic Effects of Global Supply Chain Shocks

Lapo Bini*

August 1, 2025

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A Sensitivity Checks

This appendix presents the results of a series of robustness checks on both the properties of the instrument and the stability of the main findings, including supplementary checks in addition to the tests discussed in the main text.

A.1 Diagnostics of the Instrument

To assess the validity of the instrument, I conduct a set of diagnostic checks following the approach outlined in Ramey (2016). Figure 1 plots the autocorrelation function of the FEU price surcharge series. The autocorrelations are statistically indistinguishable from zero at all lags, and the Ljung–Box Q-statistic testing the joint null hypothesis that all autocorrelations up to lag 20 are zero yields a p-value of 0.39. This provides no evidence of serial correlation.

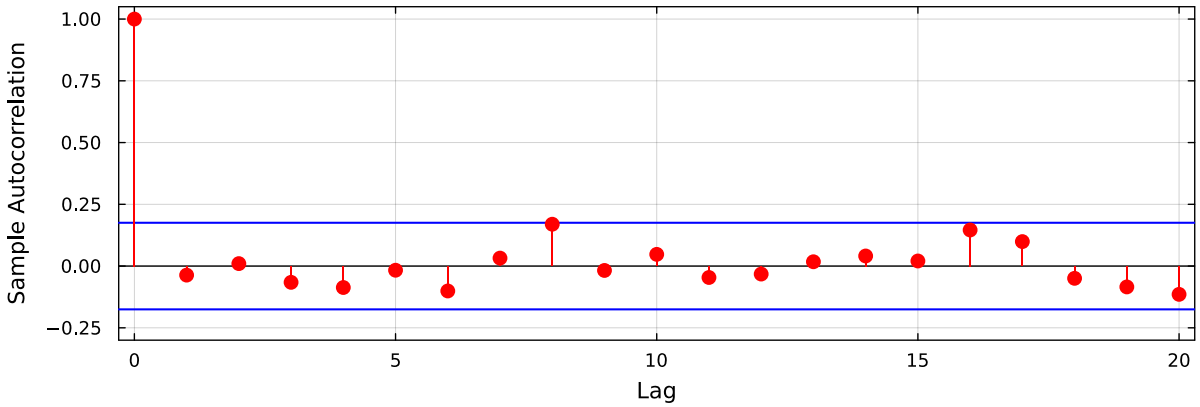


Figure 1: The Autocorrelation Function of the FEU Price Surcharge Series

*Notes:*The figure shows the autocorrelation function. The p-value for the Ljung–Box Q-statistic testing whether all autocorrelations up to lag 20 are jointly zero is 0.39.

I also examine whether the FEU price surcharge series can be forecasted using a broad set of macroeconomic variables. Table 1 reports the results of a series of Granger causality tests where the FEU price surcharge series is regressed on its own twelve lags and two lags of each control variable. The p-values are all well above conventional significance thresholds, and the null hypothesis that the instrument is not Granger-caused by other variables cannot

Table 1: Granger Causality Tests

Series	Source	Transf	p-value	F-stat	df1	df2	Sample
World Oil Production	Baumeister and Hamilton (2019)	MoM	0.76	0.27	2	98	2014M8-2024M12
US Consumer Price Index	Haver Analytics	MoM	0.56	0.58	2	98	2014M8-2024M12
US Terms of Trade	Haver Analytics	Level	0.32	1.16	2	98	2014M8-2024M12
WTI Oil Price	Haver Analytics	MoM	0.72	0.33	2	98	2014M8-2024M12
US Industrial Production	Haver Analytics	MoM	0.74	0.30	2	98	2014M8-2024M12
US Unemployment Rate	Haver Analytics	Level	0.53	0.63	2	98	2014M8-2024M12
GSCPI	Benigno et al. (2022)	Level	0.43	0.85	2	98	2014M8-2024M12
World Uncertainty Index	Ahir, Bloom and Furceri (2022)	Level	0.79	0.24	2	98	2014M8-2024M12
US Trade Policy Uncertainty Index	Baker, Bloom and Davis (2016)	Level	0.43	0.86	2	98	2014M8-2024M12
World Sentiment Index	Ahir, Bloom and Furceri (2022)	Level	0.54	0.62	2	98	2014M8-2024M12
S&P500	Haver Analytics	MoM	0.66	0.42	2	98	2014M8-2024M12
Geopolitical Risk Index	Caldara and Iacoviello (2022)	Level	0.78	0.25	2	98	2014M8-2024M12
Global Economic Condition	Baumeister, Korobilis and Lee (2022)	Level	0.78	0.25	2	98	2014M8-2024M12
Oil Price Expectations 3Months	Baumeister (2023)	Level	0.77	0.26	2	78	2014M8-2023M4
US - China Tension Index	Rogers, Sun and Sun (2024)	Level	0.61	0.50	2	89	2014M8-2024M3
Federal Funds Rate	FRED	Level	0.62	0.47	2	98	2014M8-2024M12

Note: The table shows the results of a series of Granger Causality tests of the FEU price surcharge series using a selection of macroeconomic variables. The series are made stationary when necessary by taking the MoM growth rate. The tests are conducted by regressing the shock on its own 12 lags, 2 lags of the other variable and a constant. The test is on the joint significance of the lags of the additional variable. * p<0.05, ** p<0.01, *** p<0.001.

be rejected for any series. These results suggest that the instrument is not systematically predictable based on past macroeconomic indicators or indices capturing global uncertainty, geopolitical risk, and US–China trade conditions.

Next, I assess whether the instrument is correlated with structural shock series commonly used in the literature. Table 2 reports the Pearson correlation coefficients between the FEU price surcharge series and a wide range of structural shocks, including oil demand and supply shocks, monetary policy shocks, and other shocks. None of the correlations is statistically significant. Taken together, these diagnostic results support the interpretation of the FEU price surcharge series as a valid external instrument. The series is serially uncorrelated, not forecastable from past macroeconomic variables, and orthogonal to other structural shocks commonly used in the literature, reinforcing the exogeneity condition required for Proxy-SVAR identification.

Table 2: Correlation with other Structural Shocks

Series	Source	ρ	p-value	t-stat	df	Sample
Oil News Shock	Känzig (2021)	-0.05	0.62	-0.50	123	2014M8-2024M12
Carbon News Shock	Känzig (2023)	0.11	0.37	0.91	63	2014M8-2019M12
Oil Supply Shock	Baumeister and Hamilton (2019)	-0.03	0.72	-0.36	123	2014M8-2024M12
Economic Activity Shock	Baumeister and Hamilton (2019)	0.02	0.86	0.18	123	2014M8-2024M12
Oil Consumption Demand Shock	Baumeister and Hamilton (2019)	-0.14	0.12	-1.56	123	2014M8-2024M12
Oil Inventory Demand Shock	Baumeister and Hamilton (2019)	0.01	0.91	0.12	123	2014M8-2024M12
Monetary Policy Shock	Bauer and Swanson (2023)	-0.05	0.61	-0.51	111	2014M8-2023M12

Note: The table shows the correlation of the FEU price surcharge series with a wide range of structural shocks from the literature. ρ is the Pearson correlation coefficient, the p-value corresponds to the test whether the correlation is different from zero, t-stat is the corresponding test statistic, df are the degrees of freedom. * p<0.05, ** p<0.01, *** p<0.001.

A.2 Robustness of Main Results

To ensure the reliability of the baseline results, I perform a comprehensive set of robustness checks, including tests of the invertibility assumption, lag length sensitivity, and the inclusion of additional control variables. First, I test the invertibility assumption following the procedure outlined by Plagborg-Møller and Wolf (2022) and Hamilton (Forthcoming). The first panel of Table 3 reports the p-values from a set of F-tests conducted for each equation in the baseline VAR model, for increasing lag lengths of the instrument. Across all series and lag specifications, the p-values are above conventional significance levels, indicating that the coefficients on the lagged instrument are statistically indistinguishable from zero. Moreover, the joint test of the null hypothesis that all coefficients on past realizations of the instrument are jointly zero, reported in the second panel of Table 3, cannot be rejected. Taken together, these results support the validity of the invertibility assumption and suggest that the baseline VAR does not suffer from omitted information problems.

Second, I assess the sensitivity of the aggregate IRFs to alternative lag lengths. Figure 2 displays structural impulse responses estimated from VAR specifications including 14, 16, 18, and 20 lags, in addition to the 12-lag baseline. The results are robust across specifications, with the dynamic causal effects of the global supply chain shock remaining statistically and economically consistent regardless of lag length. One exception is the WTI oil price

Table 3: Testing the invertibility assumption

Lags	US CPI	WTI Oil Price	US Ind Prod	US Unemployment	GSCPI
6	0.26	0.94	0.22	0.24	0.79
7	0.35	0.91	0.32	0.34	0.78
8	0.35	0.88	0.36	0.34	0.74
9	0.25	0.29	0.22	0.14	0.43
10	0.26	0.20	0.19	0.10	0.52
11	0.34	0.26	0.24	0.14	0.61
12	0.21	0.24	0.28	0.19	0.63

Joint test: 12 lags p-value = 0.08 F-stat = 1.31 $df_1 = 60$ $df_2 = 200$

Note: The first panel shows the p-values of a series of F-test that the coefficients $\alpha_1, \ldots, \alpha_m$ are zero in the regression $y_{it} = \pi_i' \mathbf{x}_{t-1} + \alpha_1 z_{t-1} + \cdots + \alpha_m z_{t-m} + \eta_{it}$. The test is conducted for each series included in the baseline VAR model, for different numbers of lags of the instrument. The lag order of the VAR is set to 12 and in terms of deterministics, only a constant is included. The second panel shows the joint system test across all i that lags of z do not appear in any of the equations. * p<0.05, ** p<0.01, *** p<0.001.

series, which exhibits notable variation across specifications; however, these responses are not statistically significant and have wide confidence intervals. The main takeaway is that the results are stable across lag structures and consistent with the baseline specification.

Lastly, I examine whether the impulse responses are robust to the inclusion of additional control variables. Specifically, I estimate alternative specifications of the baseline VAR model by sequentially adding one control variable at a time from a broad set of economic indicators, including price expectations, sectoral price and production indices, services, world output, interest rates, and other macro-financial variables (see Appendix C for details).

Figure 3 shows that the estimated impulse responses remain remarkably stable across these specifications. These results demonstrate that the dynamic causal effects of global supply chain shocks are robust not only to lag structure but also to the inclusion of a wide range of controls. This reinforces the credibility of the baseline findings and confirms that the main takeaway holds across alternative model specifications.

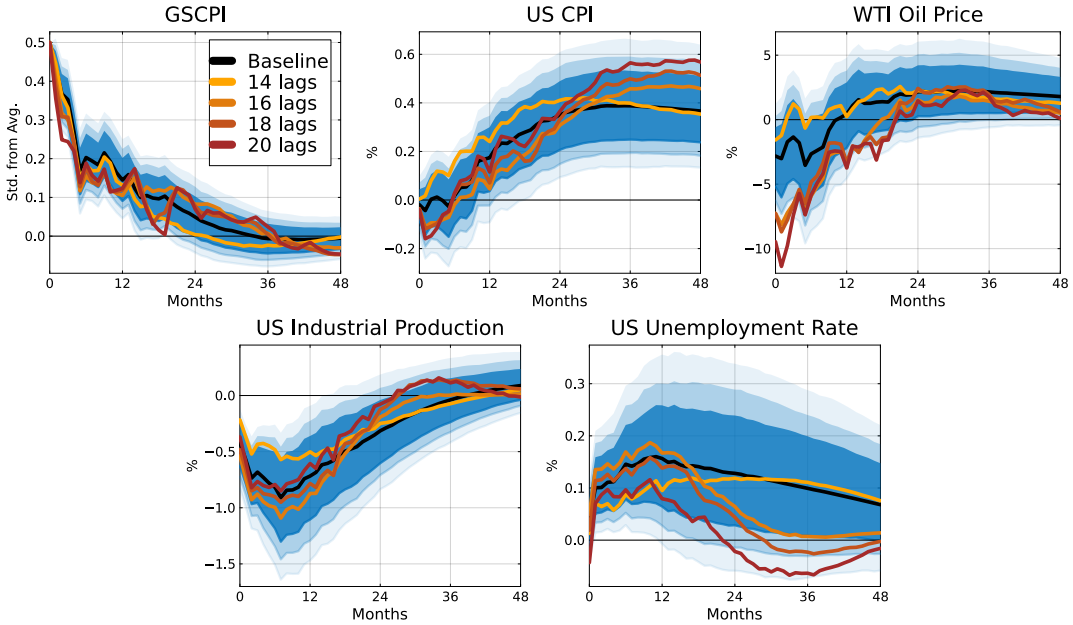


Figure 2: Robustness with respect to Lag Length

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. The solid lines are the point estimates and the shaded areas are 68, 80 and 90 percent confidence bands for the baseline model, respectively.

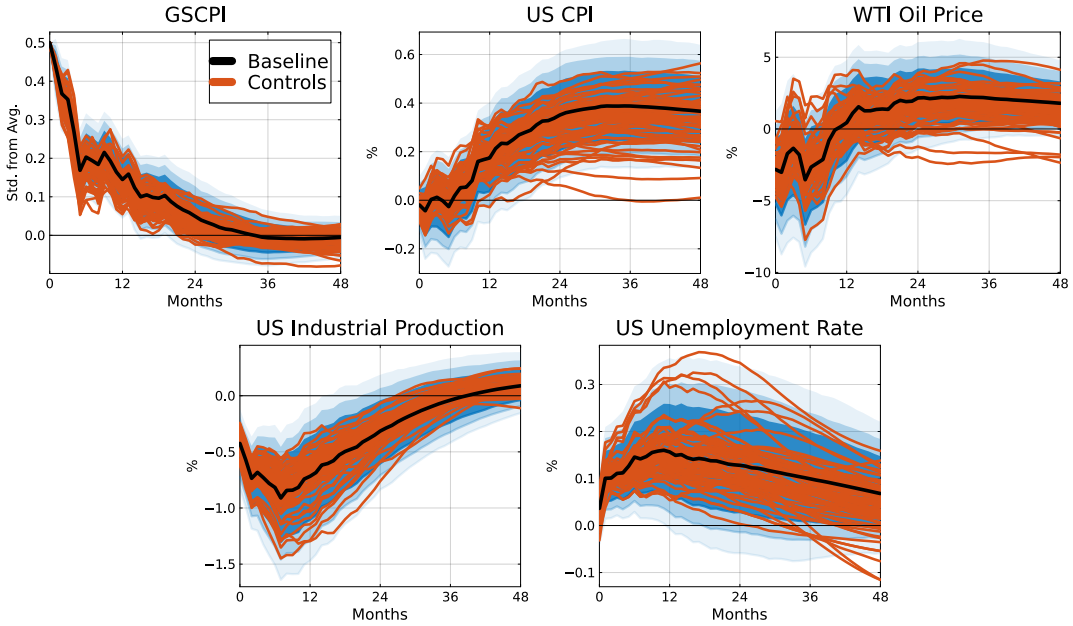


Figure 3: Robustness with respect to Additional Controls

Notes: Impulse responses to a global supply chain shock corresponding to a $1,340 price surcharge. The solid black line is the point estimate and the shaded areas are 68, 80 and 90 percent confidence bands for the baseline model. The solid orange lines are the point estimates for the model with additional controls.

B Narrative Analysis

Starting from the full set of approximately 7,000 surcharge announcements published by the world's three largest container shipping companies between 2014 and 2024, I adapt the keyword-based filtering algorithm of Baker, Bloom and Davis (2016) to isolate surcharges that include terms commonly associated with exogenous supply-side disruptions. I specify keywords related to the four broad categories of disruption described earlier:

1. **Operational disruptions:** pcs, disruption, congestion, long-time container dwell, late gate, blockage, operation cost recovery, driver, safe working practice, sanitary measure, weight charge, demolition, additional surcharge, temporary increase, stop receiving, reroute, divert, fire, damage.

2. **War-related disruptions:** emergency, extraordinary, risk, war, conflict, attack, pirate.

3. **Labor strikes and industrial action:** strike, industrial action, force majeure, work condition.

4. **Natural disasters and weather-related disruptions:** low water, water level, earthquake, drought, water conservation, cyclone, heavy rain.

To avoid inflated match counts, I search for core word stems only, treating singular and plural forms, as well as inflected verb forms, as equivalent. This automated filtering yields a set of 369 candidate announcements. Each is then subject to narrative analysis and external validation to confirm whether it reflects a genuinely exogenous supply-side disruption. One reason for exclusion is that many instances of port congestion are driven by high demand, rather than by supply-side disruptions. In addition, a considerable number of announcements are excluded because keywords appear in generic tariff breakdowns or standardized language used to describe pricing structures across routes, rather than to justify a surcharge linked to a specific event. Another reason for exclusion is the lack of supporting evidence: in some cases,

announcements refer to congestion without providing any concrete cause, and no further explanation can be found in local newspapers, industry reports, or port authority statements. I also exclude one port congestion surcharge attributed to reduced labor availability in the UK, as worker representatives cited in local media explicitly describe the surcharge as profit-driven and not reflective of actual port conditions.

Table 4 presents all 62 exogenous supply-side disruptions. For each event, I report the announcement and implementation dates, the source, the affected ports or trade routes, and the corresponding surcharge. I also provide a brief description of the disruption, including the results of the textual analysis, and offer links either to the original surcharge announcement, when sufficiently detailed, or to external sources that validate the exogenous supply-side nature of the event. To ensure that the keyword-based algorithm is not systematically missing relevant events, I manually review each of the approximately 7,000 surcharge announcements. This comprehensive review reveals five disruptions that are not captured by the algorithm but reflect clear exogenous supply-side shocks. First, I identify two announcements related to low-sulfur regulation in Chinese ports, which contain no keywords from the filtering list. However, supporting evidence from Tan et al. (2021) and Weng et al. (2022) documents how the expansion of Emission Control Areas (ECAs) and the introduction of low-sulfur regulation in China incentivize evasive routing behavior by shipping companies, thereby increasing shipping times. Second, I find three distinct events related to widespread inland transportation congestion across India's dry port network. By consulting local newspapers, I verify that these surcharges are introduced during the country's devastating second wave of COVID-19, which causes a widespread shortage of truck drivers and exposes the structural weaknesses of inland transport infrastructure. These findings are further corroborated by the timing and nature of a later event: the removal of the dry port surcharge following a sudden improvement in India's inland logistics system. This improvement is driven by a series of policy reforms, including the elimination of interstate checkpoints to reduce delivery times, the reclassification of logistics as infrastructure to attract investment, and the

completion of over 1,700 kilometers of high-capacity Dedicated Freight Corridors connecting major industrial hubs and ports.

Table 4: Collection of all the exogenous events

Event	Description	Text Analysis	Links
Port Congestion After Shipping Relocation in Sohar, Oman Announcement: 2014-08-25 Implementation: 2014-08-25 Source: MSC Europe to Sohar, Oman Surcharge: **200 USD**	Following the Eid holiday, congestion built up as all commercial shipping and cargo operations were shifted from Muscat to Sohar. The sudden surge was worsened by a backlog of empty containers awaiting export. Misaligned work schedules and disruptions across the logistics chain contributed to the gridlock. Type: operational	Extraordinary = 1, work condition = 1	logisticmid-dleeast.com
War Risk Surcharge in Hodeidah, Yemen Announcement: 2015-05-19 Implementation: 2015-05-19 Source: CMA-CGM All Trade to Hodeidah Surcharge: **600 USD**	In April 2015, a military intervention in Yemen led by Saudi Arabia and a coalition of regional countries heightened risks at Hodeidah Port, severely disrupting shipping activity. That same month, tensions in the Gulf further intensified following the brief seizure of the Maersk Tigris by Iranian forces Type: war	risk = 5, war = 2	wikipedia
Customs Delays at Shuwaikh Port, Kuwait Announcement: 2015-08-17 Implementation: 2015-08-17 Source: CMA-CGM From/to Shuwaikh Surcharge: **200 USD**	In July 2015, new customs procedures aimed at enhancing security were introduced at the port. However, the changes led to significant yard congestion, as vehicles experienced extended delays awaiting clearance. Type: operational	disruption = 2, congestion = 6	container-mag.com
Crane Failure and Sand Storm Disrupt Shuwaik, Kuwait Announcement: 2015-09-01 Implementation: 2015-09-01 Source: CMA-CGM From/to Shuwaikh Surcharge: **200 USD**	n August 2015, congestion worsened when two cranes were taken out of service due to damaged cable reels, just as a severe sandstorm swept through the region, further disrupting operations. Type: operational	disruption = 2, congestion = 6	container-mag.com
Hodeidah Port Closure After Attack Announcement: 2015-09-01 Implementation: 2015-09-01 Source: CMA-CGM To all cargo initially planned for Hodeidah (Bab-el-Mandeb) Surcharge: **400 USD**	On Monday, 17 August, an attack on the Yemeni port of Hodeidah caused extensive damage to key infrastructure, halting all operations indefinitely. As a result, the port was closed and cargo vessels were redirected to Aden. Type: war	stopped receiving = 1	msc

Crane Operators Strike at Nhava Sheva Announcement: 2015-08-07 Implementation: 2015-08-15 Source: CMA-CGM From all Asian Ports to/via Nhava Sheva Surcharge: **300 USD**	In August 2015, a week-long strike by RTG crane operators at Nhava Sheva disrupted terminal operations. Stemming from labor disputes involving outsourced workers, the strike led to severe congestion and delays in container handling. Type: strike	emergency = 5, force majeure = 1	thedollarbusiness.com
Yemen War Risk Surcharge Due to Conflict Announcement: 2015-10-21 Implementation: 2015-10-21 Source: CMA-CGM On Asia - Europe Mediterranean Trade Surcharge: **300 USD**	As the conflict in Yemen escalated nationwide, shipping faced widespread disruptions, rerouted port calls, and mounting insurance and operational costs—triggering a war risk surcharge. A blockade imposed by the Saudi-led coalition further restricted the flow of food, fuel, and medicine. Type: war	risk = 5, war = 2	securitycouncilreport
Road Construction Causing Shuwaikh Congestion Announcement: 2016-08-26 Implementation: 2016-08-26 Source: MSC World to Shuwaikh and Shuaiba, Kuwait Surcharge: **600 USD**	The launch of the Jahra Road Development Plan severely impacted direct access to Shuwaikh, causing heavy congestion on roads surrounding the terminal and disrupting port traffic flow. Type: operational	congestion = 2, demolition = 1	MSC
Bridge Demolition Disrupts Shuwaikh Access Announcement: 2016-09-06 Implementation: 2016-10-01 Source: CMA-CGM From/to Shuwaikh Surcharge: **600 USD**	The demolition of the Ghazali Bridge further restricted access to Shuwaikh, prompting the introduction of a delivery surcharge. The work supports construction of the elevated Jahra Road viaduct, aimed at improving traffic flow, separating local and through traffic, and expanding road capacity. Type: operational	disruption = 2, congestion = 6, demolition = 1	CMA - CGM
Nationwide Port Strike Disrupts Cargo in Spain Announcement: 2017-03-07 Implementation: 2017-03-10 Source: CMA-CGM All Spanish ports on Europe US Trade Surcharge: **200 USD**	A nationwide strike in Spain caused severe instability and heavy congestion across the country's ports, disrupting vessel berthing schedules. The resulting delays extended transit times and increased port-related costs for incoming cargo. Type: strike	pcs = 1, congestion = 2, emergency = 2	CMA - CGM
Weather and Hazard Disruptions in Kuwait Ports Announcement: 2017-08-21 Implementation: 2017-08-20 Source: CMA-CGM From/to Shuwaikh Surcharge: **200 USD**	In August 2017, a flammable liquid leak from a container ship disrupted operations at Kuwait's Shuaiba Port. That same month, both Shuwaikh and Shuaiba ports faced temporary shutdowns due to unstable weather, including strong winds and low visibility. Type: operational	congestion = 6	kuna.net

Port Congestion from Battle of Aden, Yemen Announcement: 2018-01-09 Implementation: 2018-01-08 Source: CMA-CGM From/to Aden Surcharge: **600 USD**	n January 2018, the Battle of Aden took place in proximity to the port, severely compromising cargo operations. The resultant instability led to substantial disruptions in cargo handling and vessel movements, contributing to significant port congestion and logistical delays. Type: war	pcs = 1, congestion = 6	wikipedia
Aden, Yemen Shipping Improves After UN Aid Plan Announcement: 2018-04-13 Implementation: 2018-04-13 Source: CMA-CGM From/to Aden Surcharge: **-200 USD**	A UN-led conference culminated in USD 2 billion in aid commitments and the adoption of an economic plan for Yemen, designed to enhance humanitarian access and streamline delivery mechanisms. The implementation of this plan improved logistical conditions. Type: war	pcs = 1, congestion = 5	news.un.org
Myanmar Port Congestion Due to Infrastructure Limits Announcement: 2018-06-01 Implementation: 2018-06-01 Source: CMA-CGM Imports into all Myanmar ports Surcharge: **200 USD**	Depots and terminals, particularly in Yangon, operated at full capacity amid a severe container backlog. Also, draft restrictions were imposed, constraining the intake capacity of all carriers. The congestion was largely attributable to inadequate port infrastructure, obsolete equipment, inefficient cargo handling practices, and a limited draft that restricted access for larger vessels. Type: operational	congestion = 6	journalofcommerce.com
Low Water Surcharge St. Lawrence Seaway, Canada Announcement: 2018-07-16 Implementation: 2018-08-01 Source: CMA-CGM From Europe and Mediterranean to Canada East Cost Surcharge: **150 USD**	In July 2017, exceptionally low water levels in the St. Lawrence River, resulting from record outflows from Lake Ontario, adversely affected commercial navigation. Vessels were compelled to operate at reduced speed and with lighter loads, diminishing overall shipping efficiency. Type: weather	low water = 2	International Lake Ontario - St. Lawrence River Board
Yangon Port Conditions Improve with Expansion Announcement: 2018-09-19 Implementation: 2018-10-01 Source: CMA-CGM Imports into all Myanmar ports Surcharge: **-200 USD**	Myanmar undertook efforts to enhance container port infrastructure in Yangon to accommodate larger vessels. The Port Authority received formal approval for the development of a new international container terminal, marking a significant step toward expanding the country's maritime capacity. Type: operational	congestion = 3	TheIrrawaddy
Port Worker Strikes Disrupt Shipping in Portugal Announcement: 2018-09-18 Implementation: 2018-10-18 Source: CMA-CGM Export from Lisbon Surcharge: **150 USD**	The surcharge was introduced following a series of strikes organized by the Sindicato dos Estivadores e da Actividade Logística in Portugal, in protest against perceived anti-union practices and exploitative labor conditions, which disrupted port operations nationwide. Type: strike	disruption = 2, congestion = 3, emergency = 1, pcs = 1	portstrategy.com

Shuwaikh Congestion from Storage Shortages Announcement: 2018-09-25 Implementation: 2018-10-25 Source: CMA-CGM From/to Shuwaikh Surcharge: **300 USD**	The congestion is largely due to deteriorating warehouses across all storage areas and insufficient open yard space. Additionally, supplier company warehouses have reached maximum capacity. Type: operational	disruption = 2, congestion = 6	AlRukaibi, AlKheder and AlMashan (2020)
Low Sulphur Surcharge and Compliance Evasion, Shangai and Ningbo. Announcement: 2018-10-31 Implementation: 2018-11-15 Source: CMA-CGM MSC From Europe destined to Ningbo and Shangai Surcharge: **46.7 USD**	A new regulation introducing a low sulphur surcharge led some carriers to avoid Emission Control Areas (ECAs) to bypass compliance. This practice extended delivery times and raised operational costs, as retrofitting vessels to meet standards was deemed prohibitively expensive. Type: operational	missing	Tan et al. (2021); Weng et al. (2022)
Aden Port Congestion from Yemen Conflict Announcement: 2018-11-28 Implementation: 2018-12-01 Source: CMA-CGM From/to Aden Surcharge: **400 USD**	On November 1, a major offensive was launched in Hodeidah by coalition-backed forces targeting Ansar Allah troops, amid escalating conflict across Yemen. Intensified ground combat and airstrikes severely disrupted port operations, resulting in heightened congestion and shipping delays. Type: war	pcs = 1, congestion = 5	Doctors Without Borders
Low Sulphur Surcharge and Compliance Evasion, extended to all China, Taiwan, Hong Kong. Announcement: 2018-12-14 Implementation: 2019-01-01 Source: CMA-CGM MSC Ex/via China, Hong Kong, Taiwan to all destinations worldwide Surcharge: **46.7 USD**	A new regulation introducing a low sulphur surcharge led some carriers to avoid Emission Control Areas (ECAs) to bypass compliance. This practice extended delivery times and raised operational costs, as retrofitting vessels was deemed prohibitively expensive. The regulation was later extended to all other Chinese ports, as well as Taiwan and Hong Kong, further amplifying its operational impact. Type: operational	missing	Tan et al. (2021); Weng et al. (2022)
Low Water Surcharge St. Lawrence Seaway, Canada Announcement: 2018-12-20 Implementation: 2019-01-17 Source: CMA-CGM From Europe and Mediterranean to Canada East Cost Surcharge: **125 USD**	In November and December 2018, Lake Ontario recorded its fourth- and fifth-highest net total supplies for those months. Despite already elevated outflows, continued inflow increases led to persistently low water levels on Lake St. Lawrence, resulting in reduced draft allowances, heightened grounding risks, and significant disruptions to commercial navigation Type: weather	low water = 2	International Lake Ontario - St. Lawrence River Board
Infrastructure Progress Reduces Congestion at Shuwaikh Announcement: 2019-05-13 Implementation: 2019-06-01 Source: CMA-CGM Shuwaikh import Surcharge: **-300 USD**	Unexpected progress in the ongoing berth development project at Shuwaikh Port contributed to a reduction in congestion and operational delays. Type: operational	congestion = 6	AlRukaibi, AlKheder and AlMashan (2020)

Strait of Hormuz Attack Triggers War Risk Surcharge Announcement: 2019-07-02 Implementation: 2019-08-01 Source: CMA-CGM MSC From/to Bahrein, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, UAE Surcharge: **76 USD**	On 13 June 2019, two oil tankers, the Kokuka Courageous and Front Altair, were attacked near the Strait of Hormuz while transiting the Gulf of Oman, sustaining fire damage reportedly caused by limpet mines or airborne projectiles. Coming shortly after a similar incident in May, the attacks led to the imposition of additional risk coverage surcharges. Type: war	risk = 2 (CMA - CGM); risk = 4, war = 4 (MSC)	wikipedia.com
Conflict-Driven Port Delays in Aden, Yemen Announcement: 2019-07-19 Implementation: 2019-08-20 Source: CMA-CGM From/to Aden Surcharge: **300 USD**	In July 2019, intensified conflict in Aden, Yemen, including fatal attacks, heightened instability around the port. The resulting disruption impaired operations, leading to congestion and delays in cargo handling. Type: war	operation cost recovery = 5	aljazeera
Transport Strikes Disrupt Shipping in South France Announcement: 2020-01-22 Implementation: 2020-02-01 Source: MAERSK From/to Southern France Surcharge: **425 USD**	Nationwide strikes in France disrupted all modes of transport, including ocean and inland services. The resulting impact on the shipping network was particularly pronounced in the southern regions, where significant operational delays were reported. Type: strike	disruption = 4, congestion = 2, emergency = 1, risk = 1, strike = 2	MAERSK
COVID Congestion Disrupts Manila Port Operations Announcement: 2020-01-28 Implementation: 2020-03-01 Source: MAERSK From/to Philippines Surcharge: **1255 USD**	Congestions occurred in all Philippine ports, particularly in Manila. Continued cargo accumulation and slow container retrieval—exacerbated by COVID-19 restrictions and labor shortages—left minimal space for new arrivals, pushing port operations toward shutdown and severely impairing shipping efficiency. Type: operational	additional surcharge = 2, low water = 1	Philippine Ports Authority
Felixstowe Congestion from COVID and Driver Shortage Announcement: 2020-09-22 Implementation: 2020-10-01 Source: CMA-CGM From/to Felixstowe to/from Far East and South East Asia Surcharge: **300 USD**	Felixstowe faced reduced terminal productivity due to newly introduced COVID-19 safety protocols and mandatory deep cleaning between shifts. A severe shortage of Heavy Goods Vehicle drivers compounded congestion, slowing container movement and raising operational costs. Compared to the same period in 2019, the port handled fewer containers, as carriers increasingly omitted Felixstowe from their rotations amid ongoing delays and difficulties in clearing space for empty returns. Type: operational	congestion = 5, driver = 1, safe working practices = 1, safe working practice = 1	metro.global.com

Australia Port Congestions from Weather and Strikes Announcement: 2020-09-08 Implementation: 2020-10-08 Source: CMA-CGM MAERSK MSC From/to Sidney, Melbourne, Brisbane Surcharge: **556.7 USD**	Shipping companies reported significant vessel delays at ports across Australia. Congestion at the Port of Sydney, initially caused by weather disruptions and later compounded by industrial action, had a cascading effect, resulting in prolonged delays at Melbourne and Brisbane ports as well. Type: strike	pcs = 1, congestion = 3, emergency = 2, industrial action = 1 (CMA - CGM); congestion = 5, industrial action = 1 (MAERSK); congestion = 5, industrial action = 1, disruption = 1 (MSC)	CMA-CGM MAERSK MSC
Bilbao Port Strike Causes Widespread Disruption Announcement: 2020-11-07 Implementation: 2020-11-16 Source: CMA-CGM MSC From/to Bilbao Surcharge: **250 USD**	Stevedores strike at the Port of Bilbao, with operations limited to 50% capacity, caused severe congestion. The disruption forced carriers to reroute vessels, leading to substantial delays and costs, with ripple effects reaching other Spanish ports. Type: strike	pcs = 1, congestion = 5 (CMA - CGM); congestion = 5, strike = 1 (MSC)	Allmed Road - Sea - Logistics
UK-Wide Port Congestion from COVID and Labor Shortages Announcement: 2020-11-19 Implementation: 2020-12-01 Source: CMA-CGM From/to all UK ports to/from Asia Surcharge: **240 USD**	Severe labor shortages caused by the intensifying second wave of COVID-19, which was approaching its peak, played a central role in disrupting operations across UK ports. Compounded by reduced terminal productivity due to strict safety protocols and mandatory deep cleaning between shifts, these shortages led to widespread congestion. The lack of available HGV drivers further slowed container movement and increased operational costs. The introduction of a second national lockdown on 5 November added further pressure to an already critical situation. Type: operational	pcs = 1, congestion = 6	metro.global.com
Inland Transport Congestion During Second COVID Wave at LA–LB Ports Announcement: 2020-11-04 Implementation: 2020-12-04 Source: MSC Deliveries made by truck or rail to Chicago, Houston, Columbus, Cincinnati, Dallas, Memphis, Nashville, St Louise, Minneapolis, LA-LB, Seattle, Oakland, Tacoma Surcharge: **700 USD**	The surcharge was introduced during the peak of the second wave of COVID-19 in California, a period marked by record case numbers, strict regional lockdowns, and the emergence of the Alpha variant, which severely congested all major seaports, particularly Los Angeles and Long Beach. The situation resulted in a severe lack of truck drivers and port labor. Notably, the surcharge applied only when MSC arranged inland transport, highlighting the challenges faced by carrier-managed intermodal services. Type: operational	congestion = 1, emergency = 4	AmericanJournalofTransportation CBSnews
Tension at the Bab-el-Mandeb Strait Announcement: 2020-11-13 Implementation: 2020-12-13 Source: CMA-CGM From/to Aden, From/to Port Sudan Surcharge: **400 USD**	In November 2020, Yemen experienced compounded disruptions, most critically from escalating conflict that intensified instability in the Bab el-Mandeb Strait. Concurrently, Tropical Cyclone Gati brought heavy rainfal and hazardous sea conditions, and a cholera outbreak further impaired port efficiency and inland logistics. Type: war	pcs = 1, congestion = 5	reliefweb WHO

Port Surcharge Due to Sanitary Protocols, US Announcement: 2021-02-04 Implementation: 2021-02-04 Source: CMA-CGM Ports of Los Angeles, Long Beach, Oakland, Seattle and Tacoma Surcharge: **3 USD**	According to the official announcement, the surcharge was introduced to offset rising operational costs associated with enhanced sanitary measures, which also contributed to reduced efficiency in container handling and overall shipping operations. Type: operational	sanitary measure = 2	CMA - CGM
Low Water Surcharge St. Lawrence Seaway, Canada Announcement: 2021-01-11 Implementation: 2021-02-07 Source: CMA-CGM From /to Canada East Cost Surcharge: **50 USD**	Low water levels in the St. Lawrence River hindered shipping operations in Canada, as vessels were required to reduce cargo loads and adopt more cautious navigation, resulting in diminished operational efficiency. Type: operational	low water = 2, water level = 1	CMA - CGM
UK Surcharge on Indian Imports Due to Colombo Congestion Announcement: 2021-03-12 Implementation: 2021-03-15 Source: CMA-CGM From India to Southampton and London Gateway Surcharge: **400 USD**	The surcharge applied exclusively to goods imported from India, reflecting severe congestion at Colombo Port in Sri Lanka. Operating at roughly 40% capacity, the port faced a significant backlog that disrupted the feeder network and delayed cargo movement from India and neighboring countries, including Bangladesh, where over 10,000 containers reportedly awaited export. Type: operational	pcs = 1, congestion = 6	PFE Express
Port Surcharge Due to Sanitary Protocols, Canada Announcement: 2021-04-01 Implementation: 2021-05-01 Source: CMA-CGM From/to Canada West Coast Surcharge: **10 USD**	According to the official announcement, the surcharge was introduced to offset rising operational costs associated with enhanced sanitary measures, which also contributed to reduced efficiency in container handling and overall shipping operations. Type: operational	sanitary measure = 2	CMA - CGM
Suez Blockage Surcharge Due to Peak Capacity Strain Announcement: 2021-05-07 Implementation: 2021-05-07 Source: MAERSK From/to Europe and Mediterranean Surcharge: **42.5215 USD**	Following the March 2021 blockage, the Suez Canal reopened to vessel transits; however, the subsequent surge in arrivals placed considerable strain on port terminals and depots. This led to prolonged waiting times across all inland transport modes. In response, a surcharge was imposed on all Carrier Haulage and Multi-Carrier shipments for the month of May. Type: operational	congestion = 1, blockage = 1, extraordinary = 1	MAERSK
Suez Blockage Surcharge Due to Peak Capacity Strain Announcement: 2021-05-07 Implementation: 2021-06-01 Source: MAERSK From/to Europe and Mediterranean Surcharge: **42.1435 USD**	The prolonged and more severe-than-anticipated impact of the Suez Canal blockage prompted shipping companies to extend the surcharge for an additional month. Type: operational	congestion = 1, blockage = 1, extraordinary = 1	MAERSK

Low Water Surcharge, St. Lawrence Seaway, Canada Announcement: 2021-06-01 Implementation: 2021-06-15 Source: CMA-CGM MAERSK MSC From Europe and Mediterranean to Canada Surcharge: **250 USD**	Extreme weather conditions led to reduced water levels on the St. Lawrence River, constraining vessel draft and limiting cargo capacity. Type: weather	low water = 2, water level = 1 (CMA - CGM); low water = 2, water level = 2 (MAERSK); low water = 3, water level = 1 (MSC)	CMA-CGM MAERSK MSC
Suez Blockage Surcharge Due to Peak Capacity Strain Announcement: 2021-06-21 Implementation: 2021-07-01 Source: MAERSK From/to Europe and Mediterranean Surcharge: **41.3875 USD**	The prolonged and more severe-than-anticipated impact of the Suez Canal blockage prompted shipping companies to extend the surcharge for an additional month. Type: operational	extraordinary = 1	MAERSK
Suez Blockage Surcharge Due to Peak Capacity Strain Announcement: 2021-07-21 Implementation: 2021-08-01 Source: MAERSK From/to Europe and Mediterranean Surcharge: **41.118 USD**	The prolonged and more severe-than-anticipated impact of the Suez Canal blockage prompted shipping companies to extend the surcharge for an additional month. Type: operational	extraordinary = 1	MAERSK
Full Closure of Meishan Terminal at Ningbo, China Amid COVID-19 Outbreak Announcement: 2021-08-03 Implementation: 2021-08-15 Source: MSC All shipment from Asia to Europe and Mediterranean Surcharge: **1000 USD**	In August 2021, China's Ningbo port (world's third busiest) shutted down the Meishan terminal following a local COVID-19 outbreak and the enforcement of strict containment measures. This was one of several partial or full closures of terminal gate operations across China between March and August 2021 due to renewed outbreaks. The disruption exacerbated ongoing congestion along the West–East trade route, compounding delays caused by the March 2021 Suez Canal blockage. Type: operational	disruption = 4	MSC CARSON-Intl MAERSK
Emergency Dwell Fees at LA–LB Triggered by Terminal Restrictions on Empty Returns Announcement: 2021-11-03 Implementation: 2021-11-01 Source: MSC Ports of Los Angeles and Long Beach Surcharge: **100 USD**	The Excess Container Dwell Fee was introduced in November 2021 to address record-high dwell times at LA–LB ports. Terminal operators had restricted the return of empty containers, preventing container swaps and turning terminals into storage yards. This led to off-terminal pileups, chassis shortages, and a breakdown in container flow. To ease yard congestion and restore operational fluidity, fees were applied to import containers dwelling over 9 days (truck) or 6 days (rail). Type: operational	disruption = 2, congestion = 2, emergency = 1	MSC FREIGHT-WAWES

Indian Inland Transportation Paralysis from COVID Trucking Shortage Announcement: 2021-11-08 Implementation: 2021-12-01 Source: MAERSK All Indian locations via Indian Ports to World Surcharge: **31.18 USD**	During the second wave of COVID-19, India experienced severe inland transportation congestion due to a critical shortage of truck drivers. Health risks, poor infrastructure, and lack of sanitation facilities left nearly 65% of the national fleet inactive, leading to significant delays and congestion at dry ports. Type: operational	missing	wikipedia.com;truck-suvidha.com
LA–LB Congestion Worsens as Dwell Times and Empties Peak Announcement: 2021-12-01 Implementation: 2021-12-29 Source: MAERSK Ports of Los Angeles and Long Beach Surcharge: **100 USD**	The surcharge reflected worsening terminal conditions, as terminals increasingly served as overflow storage sites, adding to existing delays. Despite efforts like the Emergency Dwell Fee program, congestion persisted into December, with the number of containers dwelling 13 days or more rising from 14,309 to 15,387. The situation peaked with 94 vessels waiting offshore, a record high, even though overall arrivals remained below pre-COVID levels. At the same time, empty containers piled up, reaching a peak of 90,397 units. Type: operational	temporary increase = 1	DHL;LogisticUpdateAfrica
War Risk Surcharge on Black Sea Trade Announcement: 2022-03-02 Implementation: 2022-04-03 Source: MAERSK From/to all Black Sea Ports Surcharge: **1100 USD**	In response to the conflict in Ukraine and the designation of the Black Sea as a war zone, a war risk surcharge was introduced for vessels calling at regional ports. Shipping companies faced elevated insurance costs and operational risks, along with extended transit times, cargo detention, and rerouting. Type: war	emergency = 8, risk = 8, conflict = 1	MAERSK
Port Congestion Surcharge, Le Havre Announcement: 2022-04-20 Implementation: 2022-04-19 Source: MAERSK Port of Le Havre TDF Surcharge: **135.4375 USD**	The surcharge at the Port of LeHavre was introduced in response to severe congestion at the TNMSC terminal, stemming from truck logistics and operational problems that caused significant delays in the gate in/out movement of full containers. As a direct consequence, inland transport suppliers imposed congestion surcharges for intermodal services. Type: operational	congestion = 3, extraordinary = 1	Linerlytica;MAERSK
Widespread Dry Port Congestion Surcharge in India Announcement: 2022-05-02 Implementation: 2022-06-01 Source: MAERSK All Indian locations via Indian Ports to World Surcharge: **24.71 USD**	The dry port surcharge was extended across 92 inland ports in response to the severe shortage of truck drivers and inadequate infrastructure. A sharp rise in COVID-19 cases from April 2022 further exacerbated the driver shortage. Type: operational	missing	trucksuvidha.com

Strikes in Northern Europe Announcement: 2022-09-07 Implementation: 2022-09-07 Source: MAERSK Ports of Le Havre TDF, Dunkirque Surcharge: **122.5 USD**	Since July 2022, "warning strikes" by approximately 12,000 dockworkers in German ports—including Hamburg, Bremerhaven, and Wilhelmshaven—have led to terminal shutdowns. Similar labor actions in Belgium and France further disrupted port operations, contributing to widespread delays. Type: strike	congestion = 2, extraordinary = 1	portstrategy.com
Labor Strike Fears and Rerouting Trigger Congestion at Port Houston Announcement: 2022-11-15 Implementation: 2022-12-01 Source: MAERSK Port of Houston Surcharge: **45 USD**	The surcharge at Port Houston was introduced in response to the growing congestion caused by a surge in rerouted cargo. Fearing disruptions from unresolved International Longshore and Warehouse Union (ILWU)–Pacific Maritime Association (PMA) labor talks on the West Coast, shippers redirected volumes through the Panama Canal to Gulf ports. The resulting spike in imports overwhelmed Houston's yard capacity, with terminals backed up with both loaded and empty containers. The Sustained Import Dwell Fee was introduced to encourage faster container pickup and improve terminal flow. Type: operational	late gate = 9	flexport.com Seatrade-Maritime MAERSK
Missed Appointment and Yard Congestion at LA-LB Announcement: 2022-11-22 Implementation: 2022-12-01 Source: MAERSK Ports of Los Angeles and Long Beach Surcharge: **270 USD**	A Late Gate Receiving Fee was introduced in response to persistent truck appointment no-shows, reportedly reaching up to 70%, which severely disrupted labor planning and terminal logistics, wasting significant resources, especially during weekends or late gate operations. The causes of these missed appointments were varied, including delays at other terminals or warehouses, traffic congestion, and documentation issues. As a result, yard congestion increased, further delaying normal operations. Type: operational	late gate = 9	worldcargonews.com APMTerminal
India Dry Port Surcharge Lifted After Infrastructure Reforms Announcement: 2023-01-23 Implementation: 2023-02-20 Source: MAERSK All Indian locations via Indian Ports to World Surcharge: **-250.85 USD**	The dry port surcharge in India was reduced following major improvements in inland transportation driven by key government reforms. The introduction of a unified indirect tax system eliminated interstate check-post delays, while the designation of logistics as infrastructure attracted investment in modern transport and warehousing. Over 1,700 kilometers of Dedicated Freight Corridors connecting key industrial hubs and ports enhanced reliability and reduced turnaround times. Type: operational	missing	Indian Brend Equity Foundation

Turkey Port Congestion After Earthquake Announcement: 2023-03-27 Implementation: 2023-03-27 Source: CMA-CGM From Mersin to all destinations worldwide Surcharge: **100 USD**	A devastating 7.8-magnitude earthquake struck southern Turkey in February 2023, causing extensive damage to port infrastructure and regional road networks. Trucking activity around Mersin was severely disrupted, while operations at the nearby Port of Iskenderun were suspended due to fire damage. As vessels were rerouted to Mersin, significant delays and congestion ensued. Type: weather	pcs = 3, congestion = 2	portcast.io
Turkey Port Congestion After Earthquake Announcement: 2023-04-07 Implementation: 2023-04-07 Source: CMA-CGM From North East Asia, South East Asia and Hong Kong SAR to Mersin Surcharge: **100 USD**	As conditions deteriorated, the port congestion surcharge was subsequently increased to reflect the escalating operational challenges. Type: weather	pcs = 2, congestion = 1	portcast.io
Panama Canal Surcharge Due to Drought Announcement: 2023-04-06 Implementation: 2023-06-01 Source: CMA-CGM From Northeast Asia, China to East Coast Central America Surcharge: **600 USD**	Severe drought conditions disrupted canal operations. A prolonged water shortage, intensified by the El Niño phenomenon, led the Panama Canal Authority to reduce daily vessel transits and lower maximum draft limits. AMany vessels were forced to lighten loads or reroute. Type: weather	low water = 2, water level = 1	pancanal.com
Panama Canal Surcharge Due to Drought Announcement: 2023-07-07 Implementation: 2023-08-03 Source: MAERSK All cargo transiting the Panama Canal Surcharge: **240 USD**	The Panama Canal Authority imposed restrictions on both the number and size of vessels transiting the canal, due to historically low water levels in Lake Gatun—the canal's primary water source. These limitations disrupted global shipping. Type: weather	emergency = 1, risk = 1	worldweatherattribution.org
Iskenderun Congestion After Reopening with Damaged Equipment Announcement: 2023-08-25 Implementation: 2023-09-01 Source: CMA-CGM From/to Iskenderun Turkey to/from Europe and Middle East Surcharge: **207.6 USD**	The Port of Iskenderun reopened three months after the February earthquake and subsequent fire that severely damaged its infrastructure. Post-reopening, the port faced significant congestion, extended delivery times, and operational delays due to limited and impaired equipment. Type: weather	pcs = 2, congestion = 2	Kuehne-Nagel1 Kuehne-Nagel2
Panama Canal Surcharge Due to Drought Announcement: 2023-11-23 Implementation: 2023-12-15 Source: CMA-CGM MSC All cargo transiting the Panama Canal Surcharge: **298.5 USD**	Due to ongoing drought conditions driven by the El Niño phenomenon and insufficient regional rainfall, the Panama Canal Authority reduced the maximum allowable draft from 14.94m to 13.41m. This led to higher delivery times, congestion, and operational costs. Type: weather	drought = 1, precipitation = 1, water conservation = 1 (CMA - CGM); emergency = 2, water level = 1 (MSC);	CMA-CGM MSC Descartes

Red Sea Conflict Forces Cape of Good Hope Rerouting Announcement: 2023-12-20 Implementation: 2024-01-01 Source: MSC From/to Europe and Mediterranean to/from Asia Surcharge: **891.67 USD**	The Contingency Adjustment Surcharge was introduced in response to the ongoing conflict in the Red Sea, including attacks by Houthi forces. To safeguard crews, cargo, and vessels, carriers re-routed shipments via the Cape of Good Hope, substantially extending transit times and increasing operational costs. Type: war	re-routing = 2 (CMA - CGM); disruption = 8, emergency = 4, risk = 1, re-routing = 1, divert = 5, diverting = 1 (MAERSK); divert = 1 (MSC)	CMA-CGM MAERSK MSC
Low Water Surcharge St. Lawrence Seaway, Canada Announcement: 2024-10-21 Implementation: 2024-11-01 Source: CMA-CGM MAERSK MSC From Europe and Mediterranean to Montreal, Canada Surcharge: **400 USD**	The surcharge was introduced in response to exceptionally low water levels in the St. Lawrence River, which significantly reduced tonnage capacity on trade routes from Europe to Montreal. These constraints disrupted shipping schedules and raised operational costs. Type: weather	low water = 4, water level = 1 (MSC); pcs = 5, congestion = 5 (CMA - CGM); low water = 4 (MAERSK)	CMA-CGM MAERSK MSC
Low Water Level Surcharge In North and Central America Announcement: 2024-11-04 Implementation: 2024-12-01 Source: CMA-CGM MAERSK All cargo transiting the Panama Canal Surcharge: **300 USD**	Extreme weather conditions reduced water levels in the Panama Canal, limiting vessel draft and restricting cargo capacity. Type: weather	low water = 1 (CMA - CGM); emergency = 2, risk = 2, low water = 4 (MAERSK)	CMA-CGM MAERSK

C Data

This appendix provides details on the variables used in the aggregate and sectoral analysis, as well as those included in the robustness check involving additional control variables. Specifically, Table 6 lists the series ID, series name, data source, and the transformation applied to each variable. The table is divided into panels, each containing the variables used in a specific analysis, as indicated by the corresponding panel title. All variables in Panels B through E were added individually to the baseline specification to test the robustness of the main results to additional controls (Figure 3). Variables used exclusively in the Granger causality tests (Table 1) or the correlation analysis with other structural shocks (Table 2) are not included, as their sources are already documented in the corresponding tables. All variables were used over the sample period from January 1998 to December 2024.

Table 6: Data description

Series ID	Series Name	Data Source	Transformation
Panel A. Aggregate Analysis			
GSCPI@NY	Global Supply Chain Pressure Index	New York FED	Level
S111PC@G10	US CPI	Haver Analytics	100 log
N111POIL@G10	WTI Oil Price	Haver Analytics	100 log
S111D@G10	US Industrial Production	Haver Analytics	100 log
S111ELUR@G10	US Unemployment Rate	Haver Analytics	Level
Panel B. Sectoral Production Analysis			
IPMFG@USECON	US IP Manufacturing	Haver Analytics	100 log
IPB0@USECON	US IP Mining	Haver Analytics	100 log
IPMDG@USECON	US IP Durable Goods	Haver Analytics	100 log
IPMND@USECON	US IP Nondurable Goods	Haver Analytics	100 log
IPE1T2@USECON	US IP Food and Beverages	Haver Analytics	100 log
IPG61T3@USECON	US IP Motor Vehicles and Parts	Haver Analytics	100 log
IP53@USECON	US IP Materials	Haver Analytics	100 log
IPFP@USECON	US IP Final Products	Haver Analytics	100 log
Panel C. Non-Tradable Analysis			
NMFBAIA@USECON	Services Activity Index	Haver Analytics	100 log
NMFEIA@USECON	Services Employment Index	Haver Analytics	100 log
NAPMOI@USECON	Manufacturing Production Index	Haver Analytics	100 log
Panel D. Sectoral Prices Analysis			
CPILFESL	US CPI Core	FRED	100 log
PCUCS@USECON	US CPI Services	Haver Analytics	100 log
PCUCCD@USECON	US CPI Durable Goods	Haver Analytics	100 log
PCUSND@USECON	US CPI Nondurable Goods	Haver Analytics	100 log
S111PCFB@G10	US CPI Food and Beverages	Haver Analytics	100 log
PCUTPV@USECON	US CPI New Vehicles	Haver Analytics	100 log
S111PCH@G10	US CPI Housing	Haver Analytics	100 log
S111PCM@G10	US CPI Medical Care	Haver Analytics	100 log
Panel E. Additional Controls			
H111PFTT@G10	US Terms of Trade	Haver Analytics	100 log
FFR	Fed Funds Rate	FRED	Level
CINF5@USECON	Inflation Expectations 5Y	Haver Analytics	Level
CINF1@USECON	Inflation Expectations 1Y	Haver Analytics	Level
S001DPP@G10	World Industrial Production	Haver Analytics	100 log

CUSR0000SEHF	US CPI Energy Services	FRED	100 log
PCUCC@USECON	US CPI Commodities	Haver Analytics	100 log
S111PCH@G10	US CPI Recreation	Haver Analytics	100 log
PCUHF@USECON	US CPI Fuels and Utilities	Haver Analytics	100 log
S111PCT@G10	US CPI Transportation	Haver Analytics	100 log
S111PCO@G10	US CPI Others	Haver Analytics	100 log
PCUSE@USECON	US CPI Energy	Haver Analytics	100 log
PCUTV@USECON	US CPI Motor Vehicles	Haver Analytics	100 log
PCUA@USECON	US CPI Apparel	Haver Analytics	100 log
UHFGE@USECON	US CPI Household Electricity	Haver Analytics	100 log
UHFGU@USECON	US CPI Piped Gas Service	Haver Analytics	100 log
PPIACO	US PPI	FRED	100 log
PCUOMFGOMFG	US PPI Manufacturing	FRED	100 log
PCU311311	US PPI Food Manufacturing	FRED	100 log
IP521@USECON	US IP Business Equipment	Haver Analytics	100 log
IPHT@USECON	US IP High Tech Industries	Haver Analytics	100 log
IP54@USECON	US IP Nonindustrial Supplies	Haver Analytics	100 log
IPUTL@USECON	US IP Electric and Gas Utilities	Haver Analytics	100 log
IPG3@USECON	US IP Machinery	Haver Analytics	100 log
IPG61@USECON	US IP Motor Vehicles	Haver Analytics	100 log
IPF1@USECON	US IP Wood	Haver Analytics	100 log
IPF7@USECON	US IP Nonmetallic Mineral Products	Haver Analytics	100 log
IPG1@USECON	US IP Primary Metals	Haver Analytics	100 log
IPG2@USECON	US IP Fabricated Metal Products	Haver Analytics	100 log
IPG4@USECON	US IP Comp and Elec Comp	Haver Analytics	100 log
IPG5@USECON	US IP Elec Eqpt, Appliances	Haver Analytics	100 log
IPG64T9@USECON	US IP Aerospace	Haver Analytics	100 log
IPG7@USECON	US IP Furniture	Haver Analytics	100 log
IPE1T2@USECON	US IP Food Bev and Tob	Haver Analytics	100 log
IPE3T4@USECON	US IP Textile	Haver Analytics	100 log
IPE5T6@USECON	US IP Apparel	Haver Analytics	100 log
IPF2@USECON	US IP Paper	Haver Analytics	100 log
IPF3@USECON	US IP Printing and Rel	Haver Analytics	100 log
IPF5@USECON	US IP Chemicals	Haver Analytics	100 log
IPF4@USECON	US IP Petroleum and Coal	Haver Analytics	100 log
IPF6@USECON	US IP Plastics and Rubber	Haver Analytics	100 log
IPN221113S	US IP Nuclear El Gen	FRED	100 log
IPB51222S	US IP Residential En Utilities	FRED	100 log

IPG2211S	US IP Electric Power	FRED	100 log
IPG2212S	US IP Gas Distribution	FRED	100 log
NMFVDI@USECON	Services Supplier Deliveries Index	Haver Analytics	100 log
NRSV2@USECON	Food Drinking Services	Haver Analytics	100 log
	Real Food Services (CPI Defl.)	Own Calculation	100 log
	Real Food Services (CPI Food Defl.)	Own Calculation	100 log
NAPMC@USECON	Manufacturing Composite Index	Haver Analytics	100 log
NAPMEI@USECON	Manufacturing Employment Index	Haver Analytics	100 log

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