Monetary Policy Transmission Under Supply Chain Pressures: Pre-Pandemic Evidence From the US

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Abstract

We investigate how supply chain conditions influence the transmission of monetary policy. Using a nonlinear local projection framework and a new index of supply chain conditions, we find that greater pressure on supply chains amplifies the standard effects of monetary policy on key macroeconomic variables. We argue that this is due to heightened financial frictions. Various measures of credit costs react more strongly to monetary policy when supply chain conditions are tight. The greater sensitivity of external finance premia in the high supply chain pressure state results in financially-constrained firms and households lowering their spending more following a contractionary monetary policy shock.

Keywords: Monetary policy, supply chain disruption, shock propagation

JEL Codes: E52, E23, E30

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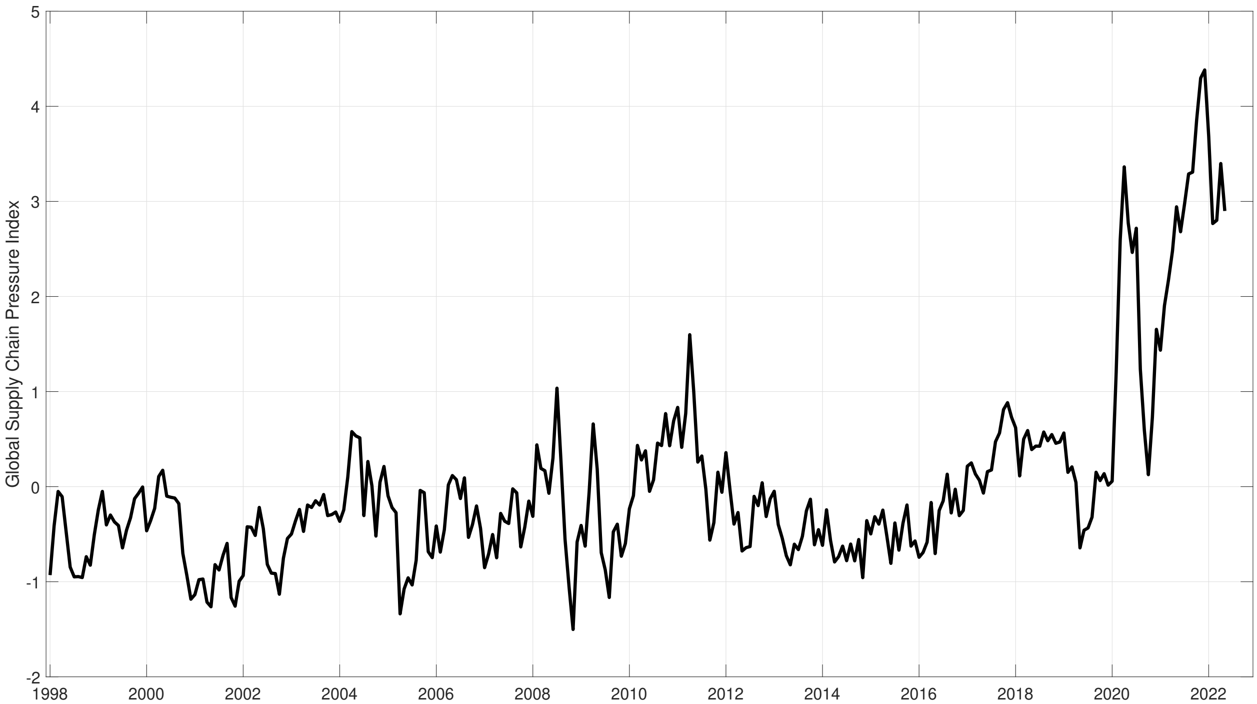
1 Introduction

The post-pandemic global economy has experienced sustained supply chain disruptions and an unprecedented tightening of monetary policy. The magnitude of supply chain stress can be observed in Figure 1, which displays the Federal Reserve Bank of New York's new Global Supply Chain Pressure Index (GSCPI) (Benigno et al., 2022). Supply chain pressures reached unprecedented heights during the pandemic, that, while peaking in December 2021, nevertheless remain at historically elevated levels. Speculation surrounding deglobalization, reshoring, and a newfound prioritization of robustness over efficiency suggest that elevated pressures may persist well beyond the reopening of the global economy. As a result, understanding the macroeconomic implications of supply chain disturbances takes on new urgency.

The most pressing challenge currently facing policymakers is combating decades-high rates of inflation. Many central banks, including the Federal Reserve in the US, are rapidly raising policy rates in an effort to restore price stability. The literature (Acemoglu et al. (2016); Carvalho and Tahbaz-Salehi (2019); Acemoglu and Tahbaz-Salehi (2020)) has suggested that supply chains, input-output linkages, and production networks can play a role in amplifying the effects of economic shocks. Indeed, Pasten et al. (2020), Ghassibe (2021), and Ozdagli and Weber (2021) among others have shown that the *existence* of input-output linkages in production networks amplify the impact of monetary policy shocks. However, the literature has yet to consider how widespread *disturbances* to production networks might influence this propagation mechanism. Given the current environment of rapid monetary tightening amid persistent supply disruptions, an improved understanding of how the state of supply chain conditions influences the transmission of monetary policy is of particular importance.

In this paper, we show that the impact of monetary policy shocks on macroeconomic outcomes is larger when supply chains face greater disruption. Specifically, we analyze how supply chain pressures in the pre-COVID era (1998-2019) influence the transmission

Figure 1: Global Supply Chain Pressure Index



Note:

of monetary policy in the United States by applying a nonlinear version of Jordà (2005)'s local projection (LP) method.[1] The method allows us to examine whether the impact of monetary policy varies with the underlying state of supply chain conditions. We find that elevated supply chain pressures amplify the otherwise standard effects of monetary policy. For instance, a contractionary monetary policy shock lowers output and inflation in any state, but significantly more so when supply chain conditions are tight.

We argue that the larger impact of monetary policy shocks on macroeconomic outcomes during times of supply chain stress occurs due to a financial friction channel. When the probability of up- and/or downstream supply chain disruption increases, there is greater uncertainty surrounding future cash flows, meaning creditors and investors will require a higher premium to compensate for additional risk. Supply chain disruptions can therefore directly increase external finance premia. Indeed, Smirnyagin and Tsyvinski (2022) report

[1]We restrict our attention to the pre-COVID era in order to avoid the outliers and potential structural breaks associated with the pandemic.

meaningful increases in equity premia across the cross-section of firms following idiosyncratic supply chain disruptions. We provide novel evidence, however, that external finance premia also become more sensitive to monetary policy when aggregate supply chain pressures are high. The impulse response functions of various credit spreads and term premia increase following a contractionary monetary policy shock in any state, but significantly more so when supply chain pressures are high. With external finance premia becoming more sensitive to monetary shocks, monetary policy, in turn, has a larger influence on aggregate demand and outcomes like output and inflation.

We use the Federal Reserve Bank of New York's Global Supply Chain Pressure Index (GSCPI) (Benigno et al., 2022) to characterize the state of supply chain conditions over our sample period. The index, displayed in Figure 1, measures the common component of several global and country-specific supply chain variables such as cross-border transportation costs, delivery times, backlogs, and inventory. The Figure shows that although global supply chain pressures have reached unprecedented levels since the onset of the pandemic, there have also been notable spikes prior to 2020, e.g., in 2008 during the Great Financial Crisis or in 2011 after the Great East Japan Earthquake. By implementing the GSCPI as a measure of aggregate supply chain conditions, we are able to investigate the influence of supply chain pressures on monetary transmission using a relatively flexible empirical strategy.

These results have important implications for the current policy environment.[2] They suggest that the expanasionary policies enacted by the Fed during the COVID-19 pandemic may have stimulated demand, and contributed to inflationary pressures, more strongly than expected due to the unprecedented degree of supply chain stress. And, while supply chain pressures have declined since the peak of the pandemic, they nevertheless have remained at historically elevated levels since the Fed initiated an aggressive tightening cycle in March 2022. Our pre-pandemic evidence, therefore, suggests that the tightening has has a higher

[2]With the caveat that many economic time series may have experienced a structural break in their data generating processes during the pandemic (Ng, 2021), in which case policy conclusions taken from pre-pandemic data should be treated with appropriate caution.

likelihood of successfully combating inflation (once appropriate lags have set in) than would be the case under average supply chain conditions. On the other hand, it also implies that a meaningful decline in inflation is likely to be accompanied by a relatively weaker real economy due to stronger contractionary effects on output and employment.

Our study is related to several strands of the literature. First, our analysis relates to the literature on the nonlinear effects of monetary policy, see e.g., Weise (1999), Garcia and Schaller (2002), Peersman and Smets (2002), Peersman and Smets (2005) or Tenreyro and Thwaites (2016). These papers analyze how the effect of monetary policy varies with the business cycle. While the earlier studies report a stronger effect of monetary policy during recessions, Tenreyro and Thwaites (2016) find that the effects of monetary policy are "less powerful" during recessions. Our study differs from the pre-existing literature by analyzing the state-dependency of monetary policy with respect to supply chain conditions. Our results show that supply chain disruptions amplify the standard effects of monetary policy on the economy. Importantly, the GSCPI is purged of demand-side factors related to business cycle fluctuations, which ensures that our results are not driven by co-movement with the business cycle.[3]

Second, our paper is also related to the literature that studies supply chains or input-output linkages as an amplification mechanism for shocks, see e.g., Acemoglu et al. (2016), Barrot and Sauvagnat (2016), Boehm et al. (2019), Acemoglu and Tahbaz-Salehi (2020) or Carvalho et al. (2021). Empirically, Barrot and Sauvagnat (2016) and Boehm et al. (2019) exploit natural disasters as exogenous shocks. They show that the shocks not only affect firms that are directly hit by the natural disasters, but also the output and sales of their direct and indirect suppliers and customers. Carvalho et al. (2021) estimate the macroeconomic effect of the 2011 Great East Japan Earthquake as well as the role of input-output linkages. They find that the decline in Japan's real GDP growth rate due to the earthquake is significantly

[3]According to Benigno et al. (2022), demand-side factors may contaminate the GSCPI to some degree around the Global Financial Crisis, however our baseline results hold even when explicitly controlling for this period.

less severe if their model omits input-output linkages. This suggests that supply chains played an important role in the amplification of the earthquake's aggregate impact.

A subset of this literature focuses on the amplification of monetary shocks. Theoretical studies such as Carvalho et al. (2021), Pasten et al. (2020), and Nakamura and Steinsson (2010) analyze the role of production networks in enhancing strategic complementarities in price setting and thus increasing short-run money non-neutrality. Ghassibe (2021) provides the first empirical evidence in favor of this view, finding that the amplification effect of input-output linkages can account for at least 30% of the overall effect of monetary shocks on aggregate consumption. While these studies focus on the downstream propagation of price rigidity through production networks, Ozdagli and Weber (2021) instead analyze the potential upstream propagation of demand shocks. They find that at least half of the effect of monetary shocks on stock returns can be attributed to indirect production network linkages. The literature has, therefore, identified important ways in which the *existence* of input-output linkages in a production network can amplify the effects of monetary policy. We build upon this pre-existing literature by analyzing the how the effect of monetary policy on macroeconomic aggregates varies with the *degree* of supply chain pressure. Using aggregate time series data in a flexible LP framework, we find that supply chain pressure amplifies the otherwise standard effects of monetary policy.

Lastly, this paper further relates to the literature on the link between monetary policy and financial frictions, see e.g., Bernanke and Gertler (1995), Bernanke et al. (1999), Gertler and Karadi (2015), and Ottonello and Winberry (2020). While Smirnyagin and Tsyvinski (2022) report that equity premia increase when individual firms are faced with idiosyncratic supply chain disruptions, we provide new evidence that credit costs also become more sensitive to monetary policy in the presence of aggregate supply chain disturbances. Specifically, we show that contractionary monetary policy shocks raise credit spreads, bond yields, and term premia *more* when supply chain pressures in the economy are high, thereby providing an economic explanation for the amplified effect of monetary policy on macroeconomic aggregates.

The paper proceeds as follow. Section 2 explains our methodology. Section 3 presents our main results. Section 4 describes our robustness checks, and section 5 provides a brief discussion of our results. Section 6 finally concludes.

2 Methodology

In this section, we describe a number of important details of our econometric methodology. We first generally explain Jordà (2005)'s local projection method that we use for our impulse response functions. We then adapt the method to our nonlinear setting. Finally, we outline the Global Supply Chain Pressure Index (GSCPI), developed by Benigno et al. (2022), which is used to capture the degree of supply chain pressure in the economy.

2.1 Local Projection Method

In this study, we use Jordà (2005)'s local projection method to estimate impulse response functions. The following equation represents the linear local projections model:

$$ln(x_{t+h}) = c^h + \sum_{j=1}^{J} \alpha_j^h ln(x_{t-j}) + \sum_{j=0}^{J} \beta_j^h shock_{t-j} + \sum_{j=0}^{J} \Gamma_j^h Z_{t-j} + \epsilon_{t+h},\ h = 0, ..., H, \tag{1}$$

where c is a constant, x is the variable of interest, *shock* is the macroeconomic shock of interest, Z is a vector of control variables, and ϵ is the residual. The local projection method involves a series of regressions for each variable of interest for each of the H impulse response horizons. The key object of interest is the parameter β_0^h. This parameter captures the effect of the macroeconomic shock on the variable of interest h periods after the shock hits the economy. The series of parameters $\{\beta_0^h\}_{h=0}^H$ then gives the impulse response function.

Here, we are interested in the macroeconomic effects of a monetary policy shock. To identify a monetary policy shock, we follow the most recent advancements in the literature and rely on high-frequency identification, e.g., following Gürkaynak et al. (2005), Gertler and Karadi (2015) and Nakamura and Steinsson (2018). The idea behind this approach is to measure changes in financial variables, e.g., short term interest rate futures, in a tight window around monetary policy announcements. So long as no other market moving events occur within the window, the change in the futures price around the announcement will capture any unanticipated change in policy. The resulting time series of "surprises" can then be interpreted as exogenous variation in monetary policy, i.e, as a measure of monetary policy shocks.

The monetary shock used in our baseline specification is constructed using four Eurodollar futures contracts, expiring 1 quarter ahead (ED1) to 4 quarters ahead (ED4). Using a range of contract horizons allows us to capture information about the short and medium term path of expected interest rates. We form our shock measure by performing a principal component analysis on the daily change in the four futures prices around an FOMC meeting. The first principal component parsimoniuously summarizes the information, accounting for over 90% of the variation across the four contracts.[4] We normalize the first principal component so that the impulse response coefficients can be interpreted as the effect of a one standard deviation increase in the 1 year ahead rate.

Local projections are easily adaptable to nonlinear or state-dependent settings like the one underlying our research question, see e.g., Jordà (2005) or Ramey and Zubairy (2018). For example, Equation 1 can be extended to

$$\begin{aligned} ln(x_{t+h}) = c^h + \sum_{j=1}^{J} \alpha_j^h ln(x_{t-j}) + \sum_{j=0}^{J} \beta_j^h mp_{t-j} + \sum_{j=0}^{J} \psi_j^h GSCPI_{t-j} \\ + \sum_{j=0}^{J} \delta_j^h GSCPI_{t-j} mp_{t-j} + \sum_{j=0}^{J} \Gamma_j^h Z_{t-j} + \epsilon_{t+h},\ h = 0, ..., H, \end{aligned} \tag{2}$$

[4] This procedure for constructing the monetary shock is essentially the same as in Nakamura and Steinsson (2018). We also use the BRW monetary shock measure from Bu et al. (2021) as a robustness check.

where $GSCPI$ is the Global Supply Chain Pressure Index (GSCPI) which is described in detail in the next subsection, and mp is the high frequency monetary policy shock. In a nutshell, the GSCPI captures the degree of pressure in global supply chains and is used here to distinguish between different states of supply chain disruptions. In Equation 2, the main objects of interest are β_0^h and δ_0^h. The GSCPI is normalized so that β_0^h measures the effect of a monetary policy shock on the variable of interest when global supply chain pressures are at their sample average, i.e., when supply chain conditions are "normal". By contrast, δ_0^h captures the *additional* impact of a monetary policy shock when global supply chain pressures are high, i.e., one standard deviation above the sample average. Accordingly, $\{\beta_0^h\}_{h=0}^H$ and $\{\beta_0^h + \delta_0^h\}_{h=0}^H$ represent the effect of the monetary policy shock when supply chain pressures are average and high, respectively. In Section 3, we use $\{\beta_0^h\}_{h=0}^H$ and $\{\beta_0^h+\delta_0^h\}_{h=0}^H$ to study the impulse responses of key economic variables to a monetary policy shock conditional on the state of supply chain disruptions. Summary statistics for all variables used in the empirical analysis are presented in Table 1.

Table 1: Summary Statistics (Jan. 1998 - Dec. 2019)

	Mean	Median	Std Dev	Min	Max	Obsv.
Monetary policy shock	0.01	0.00	0.84	-5.43	5.28	268
GSCPI	-0.25	-0.27	0.52	-1.59	1.72	268
Real GDP Growth	0.26	0.19	1.40	-7.72	16.23	268
CPI Inflation	0.18	0.18	0.28	-1.79	1.37	268
Δ Unemployment Rate	-0.01	0.00	0.16	-0.50	0.50	268
Durable Good IP	2.50	3.52	6.79	-25.17	17.18	268
Nondurable Good IP	-0.22	0.05	2.81	-12.50	4.62	268
Durable Good PPI	0.90	0.84	1.04	-1.73	3.58	268
Nondurable Good PPI	3.06	3.24	1.21	-0.22	7.06	268

Note: The table presents summary statistics for all variables used in the empirical analysis. Data is monthly over a 1998-2019 sample period.

2.2 Global Supply Chain Pressure Index

The nonlinear version of the local projection method requires a variable that captures the underlying state of the economy that the researcher wants to analyze. In this study, we are interested in how the effect of a monetary policy shock may or may not depend on supply chain disruptions. Consequently, we need to employ a variable that captures the state of supply chain pressures during our sample period. Benigno et al. (2022) from the Federal Reserve Bank of New York have developed such a variable, the Global Supply Chain Pressure Index (GSCPI).

To construct the GSCPI, the authors collect a data set with twenty-seven variables. The first set includes variables that capture cross-border transportation costs: (i) the Baltic Dry Index, (ii) the Harper Index and (iii) costs of air transportation of freight to and from the United States. The second set contains country-level manufacturing data from Purchase Manager Index (PMI) surveys: (i) delivery time, (ii) backlogs, and (iii) purchased stocks. The countries included in the data set are China, European Union, Japan, South Korea, Taiwan, the U.K. and the U.S. The authors extract principle components from this data set with twenty-seven variables. The first principle component then represents the GSCPI. The GSCPI is a monthly index beginning in 1998:01 and is shown in Figure 1.

The GSCPI is normalized so that a value of zero means supply chain pressure is at the sample average.[5] A positive value represents elevated supply chain pressure while a negative value corresponds to a low degree of supply chain pressure. Apart from a few periods, the GSCPI is negative for the early part of the sample. Hence, supply chain pressures were below average between 1998 and 2008. During the Global Financial Crisis, the GSCPI bounces up and down. In 2011, the GSCPI reaches its pre-COVID-19 peak. This is due to flooding in Thailand and the Tuhoku earthquake in Japan, which led to substantial supply chain disruptions in manufacturing even in the US, see e.g., Barrot and Sauvagnat (2016).

[5] The GSCPI as displayed in Figure 1 is normalized relative to a sample ending in 2022. In our empirical analysis, we re-normalize relative to our 1998-2019 sample period, so that a value of zero represents average pre-pandemic conditions.

Between 2012 and 2017, the GSCPI is negative before it begins to rise in 2017 due to the tariff battle between the U.S. and China (Benigno et al., 2022). Since the outbreak of the COVID-19 pandemic the GSCPI has spiked to previously unseen levels, reaching a peak in late 2021.

3 Results

In this section, we present our main results. We first show the impulse responses of macroeconomic aggregates and then the impulse responses of financial variables such as credit spreads, bond yields, and term premia. Lastly, we study the heterogeneity in the responses of different categories of production. All responses are normalized to a one standard deviation increase in the one-year Eurodollar future. Point estimates are illustrated by the blue solid line, 68-percent confidence intervals are in dark gray and 90-percent confidence intervals are in light gray with the dashed lines.

3.1 Macro Variables

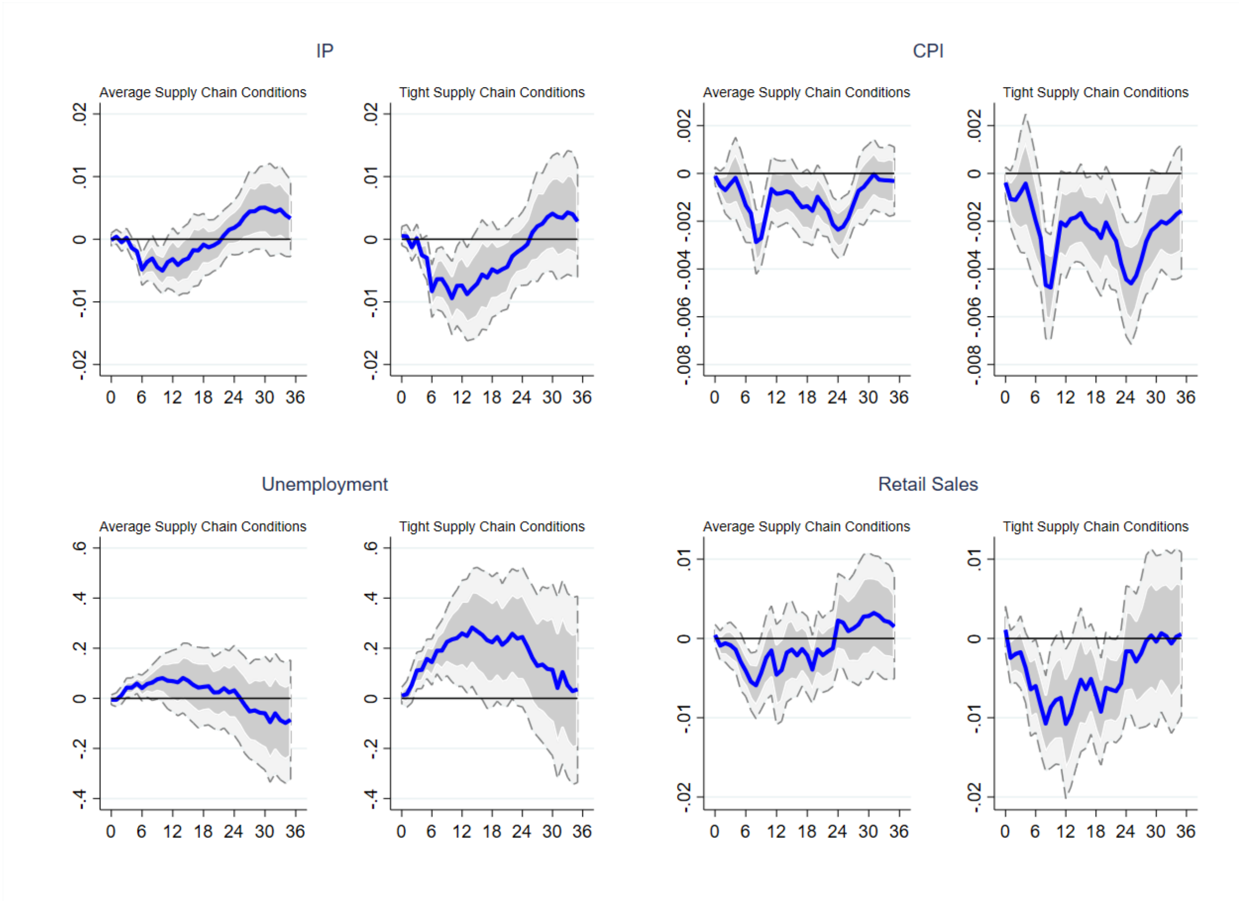
Figure 2 shows the impulse responses of industrial production, the consumer price index, the unemployment rate and retail sales to a contractionary monetary policy shock when supply chain conditions are average (left subplots) and tight (right subplots).

Table 2: Macro Responses at Trough/Peak

GSCPI*mp Coefficient			
IP	-0.0044**	CPI	-0.0021***
	(0.0018)		(0.0007)
Unemp.	0.1976***	Sales	-0.0048***
	(0.0722)		(0.0016)

Note: The table displays the coefficient on the global supply chain pressures index and monetary policy shock interaction term at the trough (peak) of the industrial production, CPI inflation, retail sales, and (unemployment) impulse responses shown in Figure 2. Newey-West standard errors are in parentheses. p<0.10; ** p<0.05; *** p<0.01.

Figure 2: Impulse Responses - Macro Variables



Note: The figure shows the impulse response of industrial production, CPI inflation, the unemployment rate and retail sales to a contractionary monetary policy shock. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The light grey shaded areas indicate 1.65 standard deviation confidence intervals and the dark grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.

Our baseline results show that heightened supply chain pressures amplify the effects of a monetary policy shock on aggregate macroeconomic outcomes. Specifically, Figure 2 shows that a contractionary monetary policy shock leads to a decline in industrial production with a short delay in both supply-chain states. Later, it leads to an insignificant increase. However, the initial decline is stronger and longer lasting when supply chains in the economy are disrupted. Furthermore, Figure 2 depicts a similar result for CPI inflation and retail sales. A contractionary shock reduces inflation and retail sales by more (at the trough) when supply chains face greater disruptions. In addition, the declines in inflation and retail sales are longer lasting. Lastly, the unemployment rate increases by a larger magnitude and for a longer duration following a contractionary shock when supply chain pressures are greater.[6] Table 2 shows that the larger response at the trough (or peak for unemployment) when supply chain pressures are high is statistically significant for all four variables. Overall, the results indicate that the standard responses of macroeconomic outcomes to a monetary shock, e.g., as shown in Gertler and Karadi (2015), are significantly larger in the face of heightened supply chain pressures.

3.2 Financial Variables

The question that naturally follows is, what explains the larger impact of monetary policy shocks in states of heightened supply chain pressure? We argue that this amplification effect occurs due to elevated financial frictions. Consider a simple illustration of the credit channel from Bean et al. (2002). The interest rate faced by firms, R_t, is equal to the risk-free rate plus an external finance premium:

$$R_t = R_t^* + f_t(D_t/E_t) \qquad (f' > 0) \tag{3}$$

where the risk-free rate is the central bank's policy tool and the external finance premium is an increasing function of a firm's debt-to-equity ratio. With the value of a firm's equity based on discounted future cash flows, an increase in the risk-free rate will lower firm equity, raise the debt-to-equity ratio, and increase the external finance premium. A policy-induced increase in the risk-free rate will, therefore, increase firm borrowing costs more than one-for-one due to the rise in the external finance premium.

We postulate that external finance premia become more sensitive to changes in the risk-

[6] Our figures display impulse responses to a positive (contractionary) shock, but it should be noted that the estimates are symmetric, i.e., flipping the sign gives the response to a negative (expansionary) shock. To test for potential asymmetry, we have also conducted the same exercise with i) only expansionary and ii) only contractionary monetary policy shocks and do not find any significant differences (results available upon request).

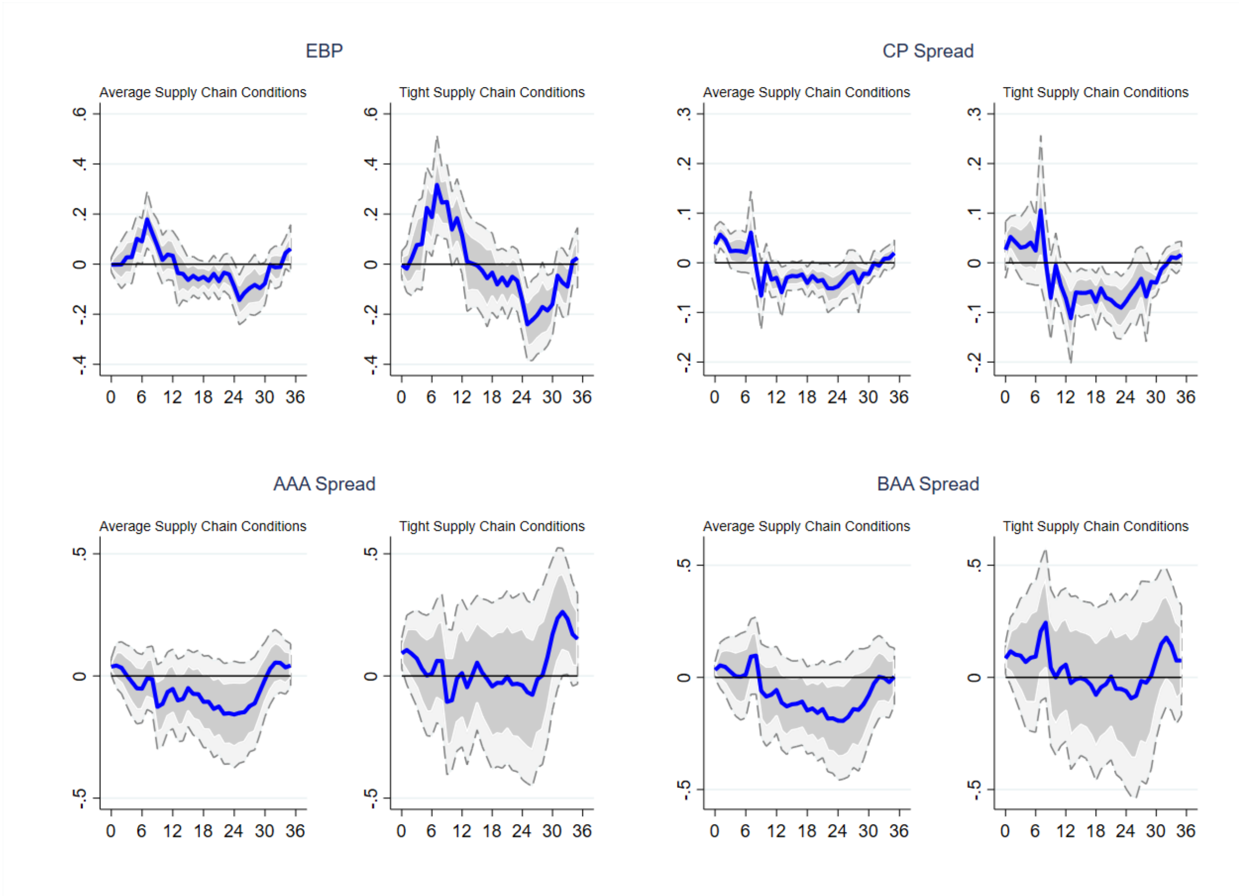
free rate in a state of heightened supply chain pressure. In the context of this simple illustration, the greater sensitivity could come from two sources: a larger downward revision in discounted expected future cash flows (E_t), or a more responsive function ($f'_{high} > f'_{average}$). While distinguishing between these two sources goes beyond the scope of our investigation, we are able to use our nonlinear LP framework to test the broader hypothesis that credit costs react more strongly to monetary policy when supply chains face greater disruption.

Specifically, we test the hypothesis that when up- and downstream supply chain disruptions become more likely, creditors will respond to higher nominal interest rates by requiring a larger premium to compensate for the additional risk. Consequently, external finance premia increase more, relative to the normal supply chain state, and monetary policy has larger economic effects. We do so by extending the nonlinear LP framework to estimate the impulse responses of a variety of financial variables. If the hypothesis is supported by the data, we shall expect that credit spreads and term premia increase more strongly following a contractionary monetary policy shock when supply chain pressure is elevated. This is precisely what we find in the data.

Figure 3 presents the impulse response functions of credit spreads. Specifically, the figure shows the response of the Gilchrist and Zakrajšek (2012) excess bond premium, the commercial paper spread over the federal funds rate, the AAA corporate bond spread over the federal funds rate, and the BAA corporate bond spread over the federal funds rate. Figure 3 documents a larger response of the credit spreads when supply chain pressures are elevated. Shortly after the shock, the credit cost measures increase in both supply chain states. However, the increase is more pronounced when supply chain pressures are high. As shown in Table 3, the larger increase is statistically significant at the peak for the excess bond premium (EBP) and the AAA spread.

The significantly larger response under tight supply chains for the EBP is particularly notable. The EBP measures the portion of the interest rate spread between an index of corporate bonds and an equivalent maturity government bond that is not due to default

Figure 3: Impulse Responses - Credit Spreads

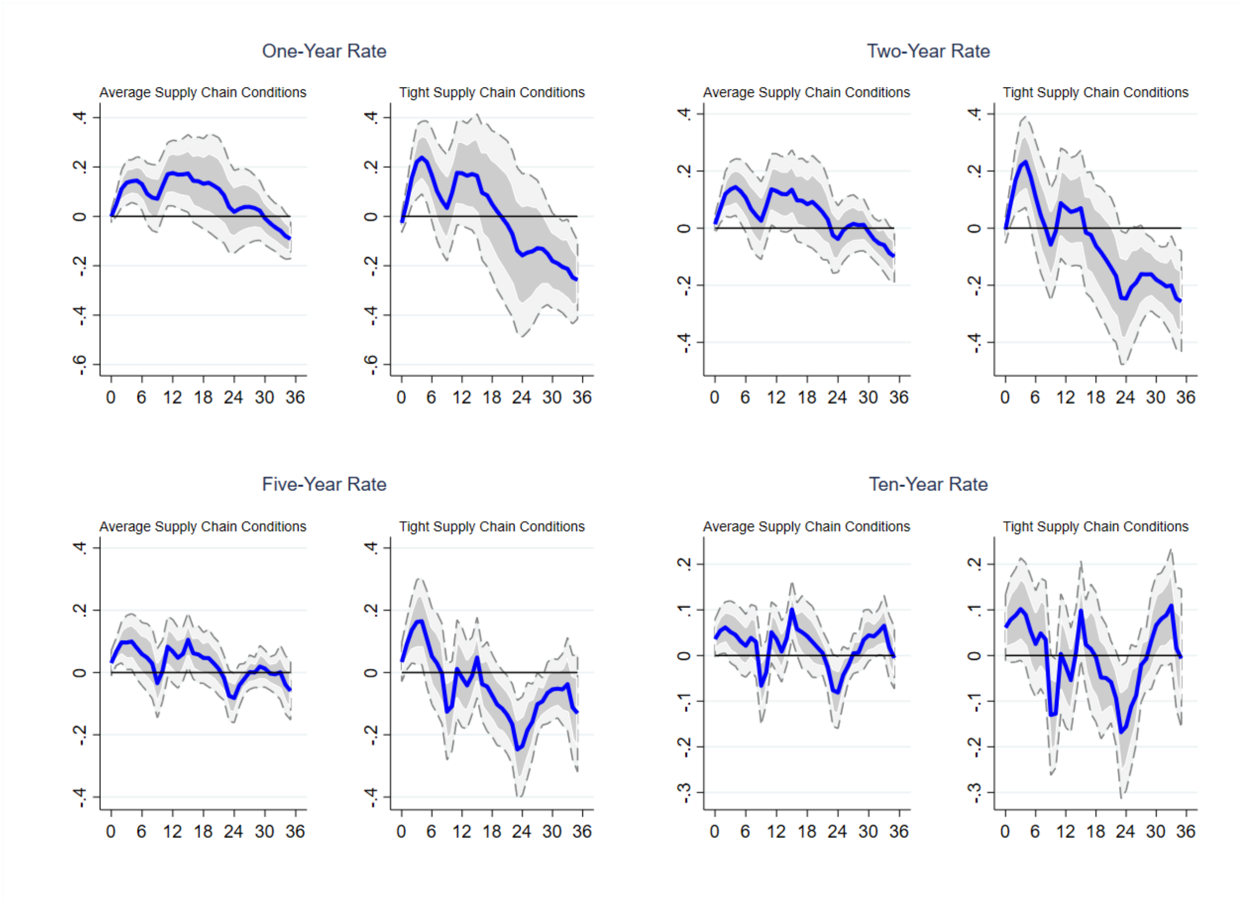


Note: The figure shows the impulse response of the excess bond premium, commercial paper spread, AAA bond spread, and BAA bond spread to a contractionary monetary policy shock. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The light grey shaded areas indicate 1.65 standard deviation confidence intervals and the dark grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.

risk. It can therefore be interpreted as the difference in credit costs between otherwise equivalent private and government securities that is attributable to the existence of financial frictions. Furthermore, Gilchrist and Zakrajšek (2012) show that the EBP has the strongest forecasting power for economic activity relative to other financial indicators. While we qualitatively observe larger increases in credit spreads across all four measures, the fact that the peak EBP response is roughly 80% larger under tight supply chain conditions offers the strongest evidence in favor of the elevated financial frictions hypothesis.[7]

[7]The peak EBP response occurs 7 months after the shock. It is 0.18 basis points under average supply

Figure 4: Impulse Responses - Bond Yields



Note: The figure shows the impulse response of the one-year rate, two-year rate, five-year rate, and ten-year rate on US Treasuries to a contractionary monetary policy shock. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The light grey shaded areas indicate 1.65 standard deviation confidence intervals and the dark grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.

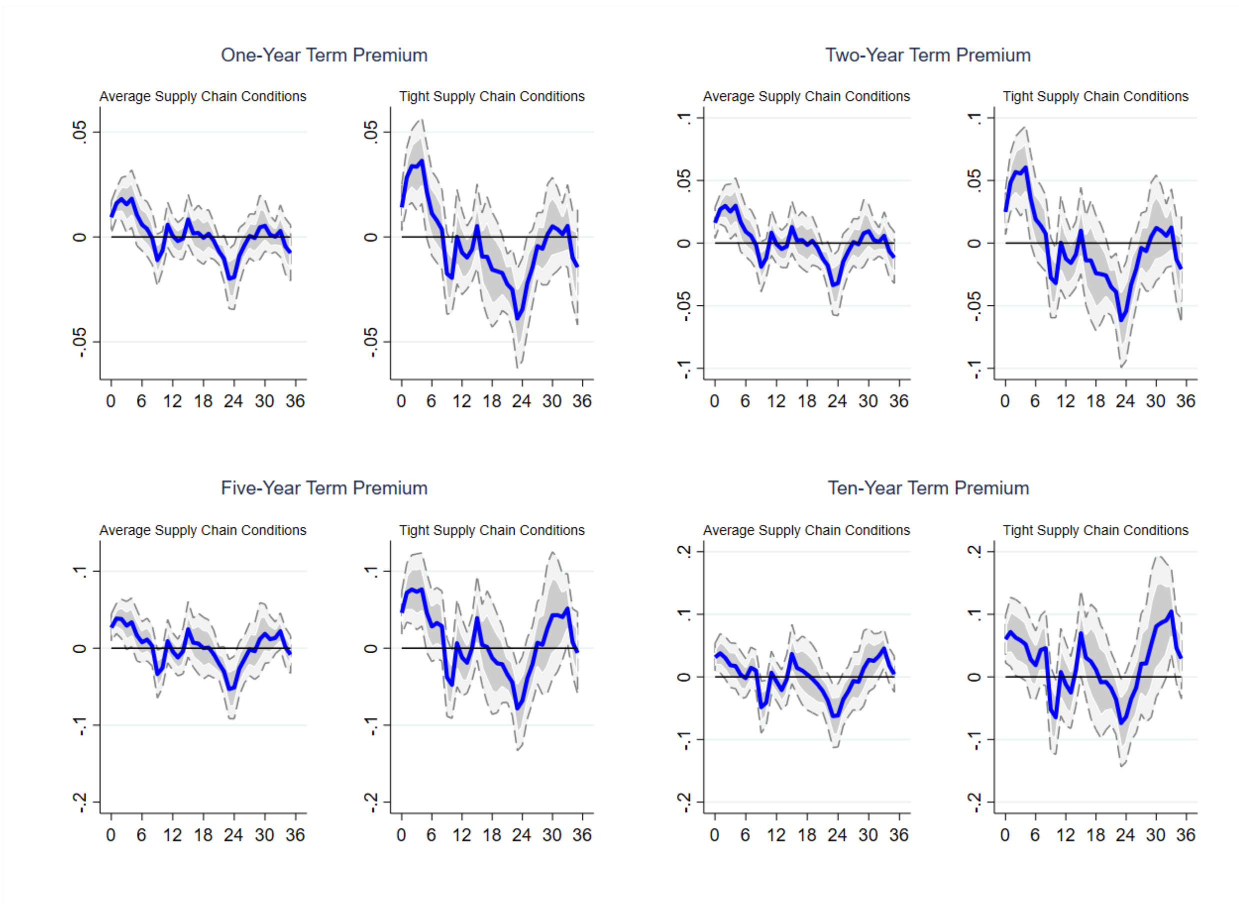
Figures 4 shows the responses of the market yield on US Treasury Securities at one-year constant maturity, two-year constant maturity, five-year constant maturity, and ten-year constant maturity to monetary policy shocks under average and tight supply chain conditions. Once again, the responses are larger when supply chain pressures are elevated, significantly so at the peak for all but the ten-year. Figure 5 in turn shows that these increases in nominal rates are largely driven by increases in term premia.[8] As shown in

chain conditions and 0.32 basis points under tight supply chain conditions. The null that the responses are statistically equivalent is rejected with a p-value of 0.037.

[8]The term premia are constructed through the Kim and Wright (2005) methodology and obtained from

Table 3, the term premium on all four maturities experience a significantly larger response to a monetary shock under tightened supply chain conditions. As term premia represent the extra return that investors require to take on the risk associated with a longer term security, their greater sensitivity offers additional evidence for our hypothesis. Overall, the larger response of credit spreads and term premia to monetary policy shocks are consistent with heightened financial frictions when the economy faces greater supply chain pressures.

Figure 5: Impulse Responses - Term Premia



Note: The figure shows the impulse response of the one-year term premium, two-year term premium, five-year term premium, and ten-year term premium on US Treasuries to a contractionary monetary policy shock. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The light grey shaded areas indicate 1.65 standard deviation confidence intervals and the dark grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.

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the FRED database.

Table 3: Financial Responses at Peak

GSCPI*mp Coefficient					
EBP	0.1379**	1-year	0.0956**	1-year TP	0.0181***
	(0.0657)		(0.0458)		(0.0057)
Aaa	0.2078**	2-year	0.1448**	2-year TP	0.0306***
	(0.1007)		(0.0610)		(0.0096)
CP	0.0448	5-year	0.0654*	5-year TP	0.0427***
	(0.0431)		(0.0368)		(0.0141)
Baa	0.1466	10-year	0.0500	10-year TP	0.0591**
	(0.1311)		(0.0332)		(0.0289)

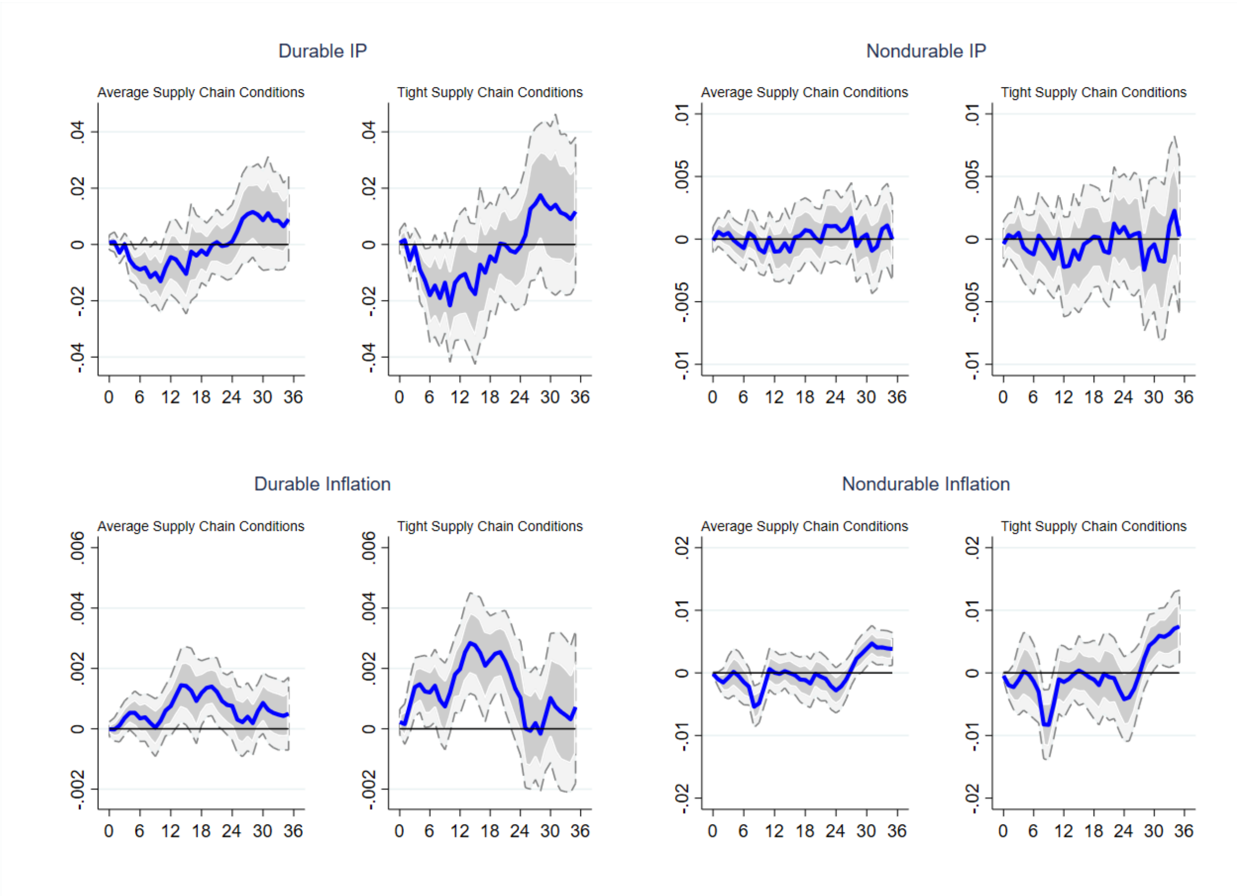
Note: The table displays the coefficient on the global supply chain pressures index and monetary policy shock interaction term at the peak of the financial variable impulse responses shown in Figures 3-5. Newey-West standard errors are in parentheses. p<0.10; ** p<0.05; *** p<0.01.

3.3 Heterogeneity in Goods Categories

Having provided intial evidence that supply chain conditions influence the transmission of monetary policy shocks to macroeconomic outcomes through elevated financial frictions, we next aim to provide some secondary support for the hypothesis. Figure 2 shows that industrial production, in general, declines more in response to a contractionary shock when supply chain conditions are tighter. If, as we argue, this general decline is driven by heightened financial frictions, we should also expect some heterogeneity in the production responses of different categories of goods. It is well known that durable goods are more sensitive to interest rate fluctuations and credit costs than nondurable goods. In an environment of heightened financial frictions, we should therefore expect to see a larger differential effect on durable good production when supply chains are tight than on nondurable good production. Again, this is precisely what we see in the data.

Figure 6 shows the impulse responses for durable and nondurable industrial production, as well as for durable and nondurable PCE inflation. The patterns observed in the top row of Figure 6 are consistent with the expected differential reactions. First, production of durable goods decreases following a contractionary monetary policy shock in both supply chain pres-

Figure 6: Impulse Responses - Durable and Nondurable Production



Note: The figure shows the impulse response of durable good industrial production, nondurable good industrial production, durable good PCE inflation, and nondurable good PCE inflation to a contractionary monetary policy shock. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The dark grey shaded areas indicate 1.65 standard deviation confidence intervals and the light grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.

sure states. By contrast, nondurable production does not show a significant reaction in either. Second, the negative reaction of durable production is larger (at the trough) and more persistent when supply chain pressure is high. The heterogeneous responses of durable and nondurable production, conditional on supply chain conditions, provides further corroboration for the view that the effects of monetary shocks are amplified under supply chain distress via elevated financial frictions.

Interestingly, we also notice heterogeneous responses of durable and nondurable inflation. Under average supply chain conditions, there is a marginally significant increase in durable good inflation and a marginally significant decrease in nondurable inflation. Under tight supply chain conditions, these divergent responses become larger in magnitude as there is a signficantly higher increase in durable good inflation and a larger decrease in nodurable inflation. The former can perhaps shed additional light on the post-pandemic surge in inflation, as the US experienced a marked shift in the composition of consumption towards durables (Tauber and Van Zandweghe, 2021) while supply chains were under greatest stress.

4 Robustness Analysis

One concern with our empirical approach is that the GSCPI may be contaminated with demand-side factors, in which case the amplified effects of monetary policy in the high GSCPI state may be due to causes unrelated to the state of global supply chains. Benigno et al. (2022) argue that the index is purged of demand-side influence for the majority of our sample period, with the caveat that its dynamics during the Global Financial Crisis likely capture some demand components. To check for the influence of the period around the GFC, we include in equation 2 a Great Recession dummy (taking a value of one from Dececember 2007 to June 2009) and its interactions with $GSCPI$, mp, and $GSCPI * mp$. The resulting impulse responses, shown in Appendix Figure A.1 are very similar to our baseline results, even when controlling for potential differential effects around the GFC.

A second concern is that our monetary policy shock measure may be contaminated by central bank information effects. To check whether information effects, i.e., news shocks related to how the Fed views the underlying state of the economy, are biasing our results, we re-estimate equation 2 with an alternative monetary shock from Bu et al. (2021) which cleanses potential information effects. The impulse responses, shown in Appendix Figure A.2, are once again very similar to our baseline results.[9]

[9]While the magnitude of the responses differ due to a different scaling of the BRW shock, the pattern of the responses are nearly identical.

5 Discussion

Our results indicate that heightened supply chain pressures increase financial frictions, which in turn, amplify the transmission of monetary policy to economic activity. Of particular interest given current circumstances, is the result that monetary tightening brings inflation down by *more* when supply chain conditions are tight. This suggests a higher likelihood of recent tightening efforts by the Federal Reserve successfully bringing down the decades-high rates of inflation faced in the aftermath of the COVID-19 pandemic, once sufficient lags have kicked in. One caveat is that our analysis is based on pre-pandemic data. It can be argued that developments around the pandemic, such as deglobalization, reshoring, and broader geopolitical disruptions represent a structural break in the data generating processes of many macroeconomic time series, in which case policy implications derived from our pre-pandemic analysis should be treated with appropriate caution.

6 Conclusion

In this paper we investigate how supply chain conditions impact the effectiveness of monetary policy using a nonlinear local projection framework and the novel Global Supply Chain Pressure Index developed by Benigno et al. (2022) for pre-pandemic US data. Our findings show that greater pressures on supply chains amplify the standard effects of monetary policy on industrial production, inflation, unemployment and retail sales. We argue that this is due to elevated financial frictions: when supply chain pressure is high, the costs of obtaining credit become more sensitive to monetary policy compared to when supply chain pressures are average. Indeed, our results shows that a contractionary monetary policy shock increases credit spreads and term premia in any state, but significantly more so in periods with greater supply chain pressure.

More empirical research on how supply chain disruptions influence macroeconomic outcomes is clearly needed. Such reserarch is particularly relevant, as the post-pandemic global economy begins a potentially bumpy transition towards less efficient, but more resilient supply chain configurations. As more data becomes available, it will be especially interesting to investigate how the unprecedented supply chain disruptions associated with COVID-19 may have influenced the relationship between monetary policy and inflation.

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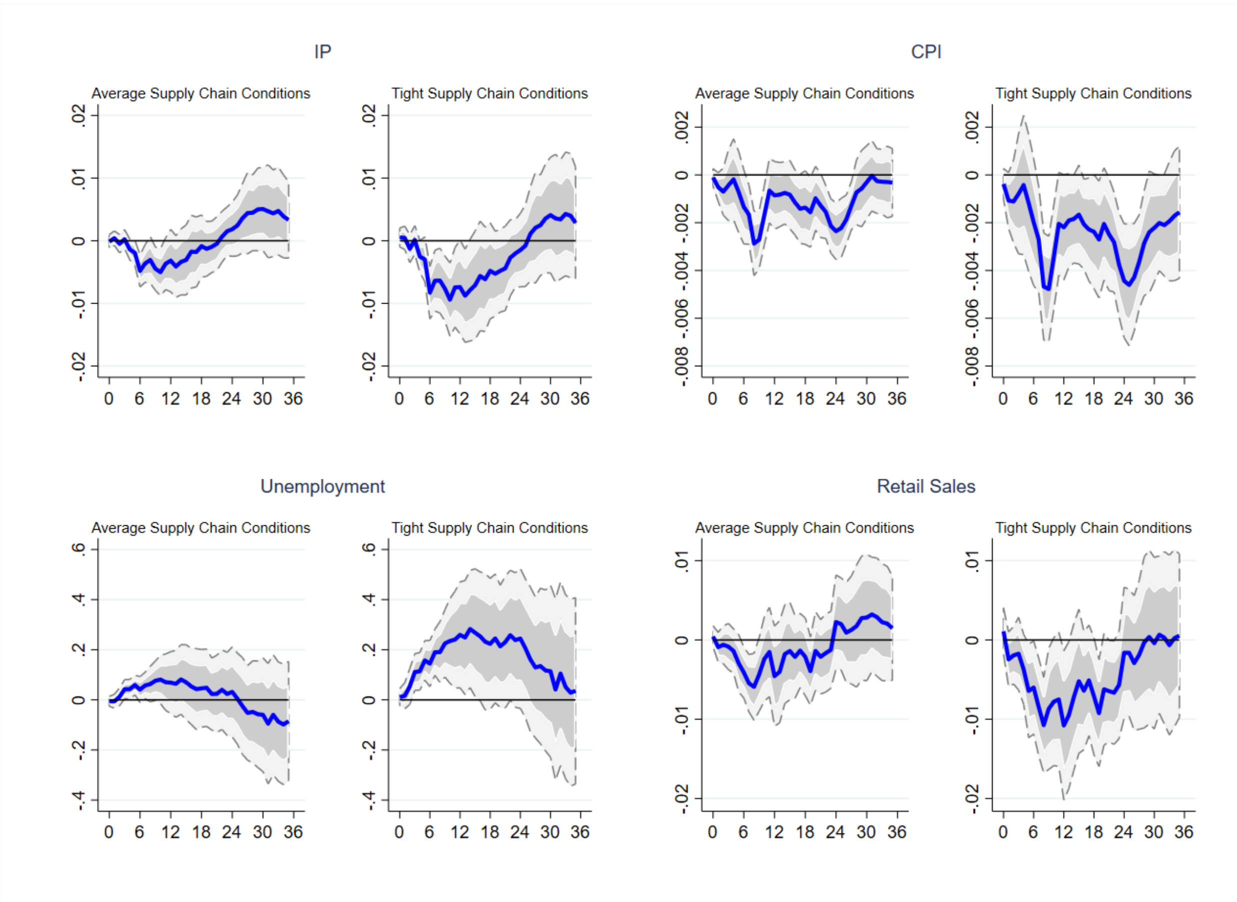
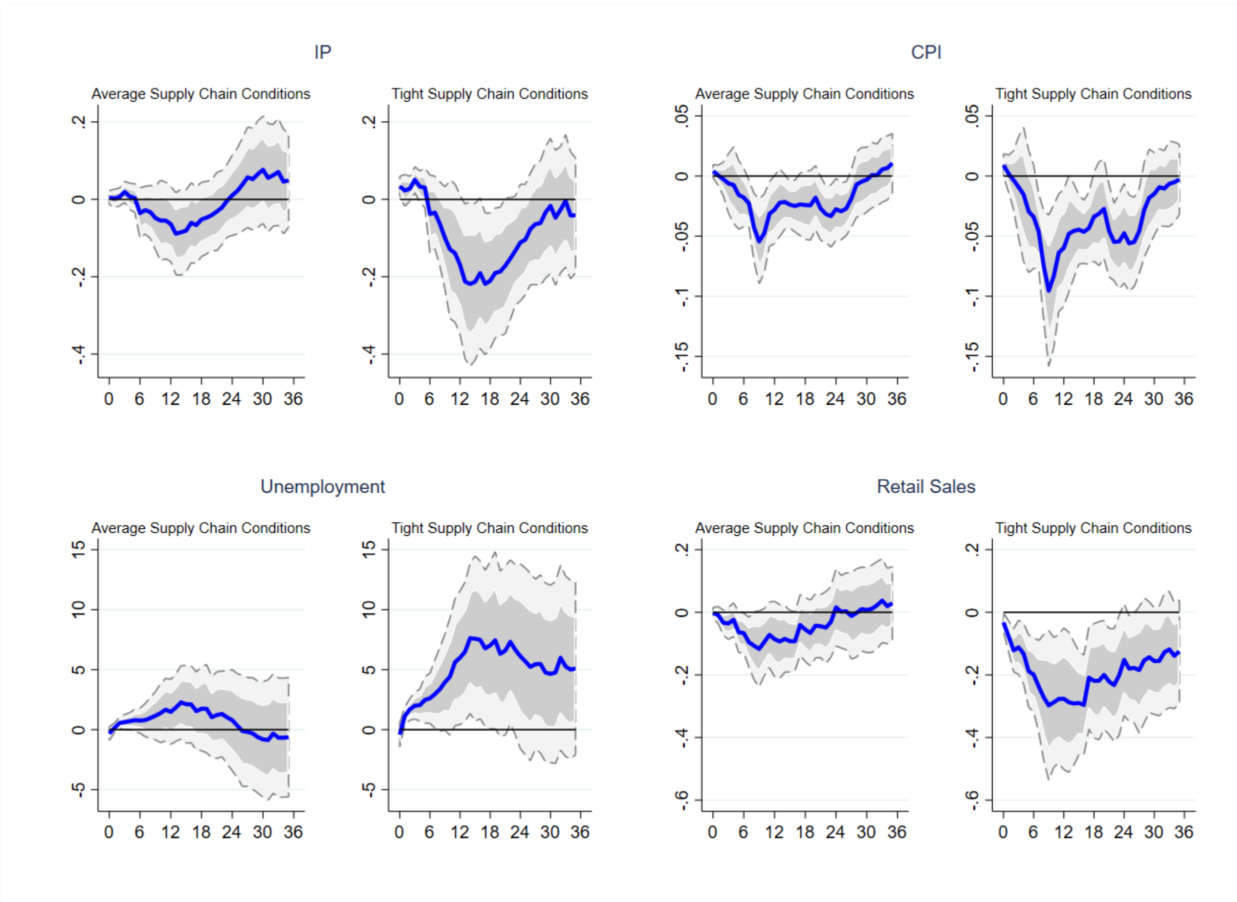
A Appendix

Figure A.1: Robustness - Great Recession



Note: The figure shows the impulse response of industrial production, CPI inflation, the unemployment rate and retail sales to a contractionary monetary policy shock. A Great Recession dummy variable equalling one from December 2007 through June 2009 is included as a control variable, along with its interaction with $GSCPI$, mp, and $GSCPI * mp$. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The light grey shaded areas indicate 1.65 standard deviation confidence intervals and the dark grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.

Figure A.2: Robustness - Information Effects



Note: The figure shows the impulse response of industrial production, CPI inflation, the unemployment rate and retail sales to a contractionary monetary policy shock. The monetary policy measure is the Bu-Rogers-Wu shock which is cleansed of central bank information effects. The left panel shows the response when supply pressures are average. The right panel shows the response when supply pressures are one standard deviation above average. The light grey shaded areas indicate 1.65 standard deviation confidence intervals and the dark grey shaded areas indicate 1 standard deviation confidence intervals constructed from Newey-West standard errors.