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Impact of supply chain pressure on macroeconomy and stock returns – Evidence from US aggregate and sectoral markets

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Abstract

This study examines the impact of supply chain pressure on macroeconomic variables and stock returns in the U.S. from January 1998 to February 2022, after controlling for monetary policy uncertainty and oil price shock. It is found that change in supply chain pressure has a positive impact on inflation and aggregate stock return and a negative impact on change in industrial output. With respect to the sectoral returns, evidence shows that change in supply chain pressure usually has a positive impact on Basic materials, Consumer staples, Industrials, and Real estate returns. However, during the Covid-19 pandemic, change in supply chain pressure has a significant and negative impact on industrial output and stock return.

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Section 1. Introduction

The Covid-19 pandemic in 2020 has brought supply chain issues to the public attention as heightened supply chain pressure due to labor shortage and shutdown of cities and countries has affected business production as well as individual consumption behavior. This paper will examine the impact of supply chain pressure change on inflation, industrial production and stock return in a system of equations in the U.S. The focus on the U.S. stems from recent research that argue about how supply chain disruptions have, to a large extent, caused the recent high inflation (for example, Ruge-Mucia & Wolman, 2022) as well as policy reports such as "The Global Supply Side of Inflationary Pressures" published by New York Fed. [1] This research is different from the research in China (Wang, Dong and Liu, 2022) in that our study more broadly defines supply chain pressure change during the 24-year sample rather than only focusing on one-time event (lock down of Wuhan, the epicenter of where Covid-19 started). This allows us to look at the impact of supply chain pressure change during the pandemic lockdown period in the U.S. as compared to that during the other periods.

The literature on supply chain disruptions is extensive, mostly in operations research and crisis management areas (see systematic reviews by Natarajarathinam et al, 2009; Durugbo and Al-Balushi, 2022). It focuses on the operations of a firm and how a firm could be better prepared in times of supply chain disruptions on planning, executing and reporting. The empirical studies are usually based on firm level data in one specific sector or for one specific event and investigate how a firm could be affected in its inventory, sales, and/or other operating-related measures as well as its stock price (Hendricks, et al, 2003, 2005, 2020; He et al, 2020; Wang et al, 2022).

The study of supply chain disruptions on the macroeconomy has been scarce. Some studies on the macroeconomic effect of natural disasters, such as hurricanes, drought or other climate-related events, find that these events reduce the economic output growth by at least .6% (Raddatz, 2009; Strobl, 2012). A recent study by Carvalho, et al. (2021) ties the natural disaster to supply chain disruption and investigates the macroeconomic effect of Japan's earthquake in 2011. By looking into firms' supplier and customer information using input-output modelling, the study finds that the earthquake has resulted in a negative .47% impact on Japan's real GDP growth rate in the year after the earthquake. Acemoglu and Tahbaz-Salehi (2024) develops a theoretical model showing that complex supply chains improve productivity due to relationship-specific investment. Disruptions to the supply chains could destroy these investments and productivities, therefore leading to decreased aggregate output.

On the other hand, Alessandria et al. (2023) focuses on how supply chain disruptions during the pandemic in 2020-2022 increase inflation. Increases in shipping time leads to lower inventory, higher import cost, lower output and higher inflation. There have been plenty of studies that examine the supply chain issue on stock performance at the firm level (Hendricks and Singhal, 2005; Wang, Dong and Liu, 2022), and most studies employ the event study approach. However, most of these studies only study the impact of large supply chain disruptions on economic output and inflation, not considering the macroeconomic impact of supply chain pressure, which sometimes may not be significant enough to affect the output and inflation. [2]

Inflation and real economic output have long been found to have a negative relationship, especially in developed countries (see a survey from Akinsola and Odhiambo, 2017). Studies that focus on relationship between inflation and real stock return have generally found a negative

[1] https://libertystreeteconomics.newyorkfed.org/2022/01/the-global-supply-side-of-inflationary-pressures/

[2] Acemoglu and Tahbaz-Salehi (2024) argues that small shocks are only marginally magnified, suggesting that macroeconomy will not be impacted significantly by small supply chain disruptions.

relationship stemming from Fama (1981)'s "proxy hypothesis". It states that the negative relationship is due to a positive relationship between real output and real stock return and a negative relationship between real output and inflation. This proxy hypothesis has been supported by a number of studies (for example, Balduzzi, 1995; Gallagher and Taylor, 2002) involving the U.S. market. It does not contradict Fisher's hypothesis that nominal stock return is positively related to expected inflation, which also finds support in later empirical studies, especially over long horizons (for example, Boudoukh and Richardson, 1993; Wong and Wu, 2010; Toyoshima and Hamori, 2011). The literature on inflation, economic output and stock returns warrants the use of a Vector Autoregressive Regression (VAR) model that considers the dynamic relationship among the three variables. Different from event studies used by Hendricks et al. (2003, 2005, 2020) and Wang et al. (2022), this study does not have an identified event, rather focus on the impact of supply chain pressure change over time. Event studies do not usually consider other variables when calculating abnormal returns other than market returns or Fama-French factors. On the other hand, the VAR model can investigate the dynamic relationship among different variables over a long time period but also include certain events using dummy variables if interest exists.

The recent outbreak of Covid-19 provides a great opportunity to study how the event disrupted the global supply chain and pushed up the prices for almost everything in our life. Di Giovanni, et al (2022) find that the global supply chain disruptions had a greater impact on the Euro Area inflation than the domestic aggregate demand shocks LaBelle and Santacreu (2022) argue that different industry exposure to global supply chain bottlenecks results in cross-industry PPI inflation during the pandemic. These studies only focus on the short period during the Covid-19 and do not look beyond the pre-pandemic period to examine the overall effect from global supply chain pressure change, which our study will be able to investigate with the use of the Global Supply Chain Pressure Index (*GSCPI*) over a relatively long period of time. In the recent two years, many studies have focused on the impact of Covid-19 cases on firm's financial performance (Ashraf, 2020; Devi et al, 2020; Latif et al, 2021). However, none of these studies ties the pandemic to the supply chain issue, which becomes the focus of concern for firm performance and overall economic performance.

This paper contributes to the current literature in the following aspects. First, it has come to light that supply constraints during the pandemic could cause significant problems for retailers, automobile companies, manufacturers and more. How the shocks in the supply side factors could affect economic growth, inflation and stock return is the focus of this study. The availability of *GSCPI* makes this study possible. Second, some sectors such as industrials, basic materials, etc. are perceived to be affected more by supply chain pressure change than the other sectors. [3] A more in-depth analysis is needed to examine how supply chain pressure change impacts different sectors in the U.S., especially during the Covid-19 disruptions in the months of March to May of 2020. Third, the different impacts of supply chain pressure change on industrial output growth, inflation and stock returns during the pandemic are identified and investigated further as compared to normal times. Fourth, two important exogenous variables, oil price shock and monetary policy uncertainty are shocks included as control variables, since these two risk factors have long been considered important factors that affect macroeconomy (for example, Segal (2011) and Sadorsky (1999) on oil price shocks and Chiang (2021) and Chen and Chiang, 2020) on monetary policy uncertainty).

[3] There have been inconsistent findings from studies such as He et al (2020), Wang et al (2022) and Baghersad and Zobel (2021).

The rest of the paper is organized as follows. Section 2 introduces the data and variables used and descriptive statistics. Section 3 explains the methodology used. Section 4 discusses the empirical results of different models and Section 5 concludes.

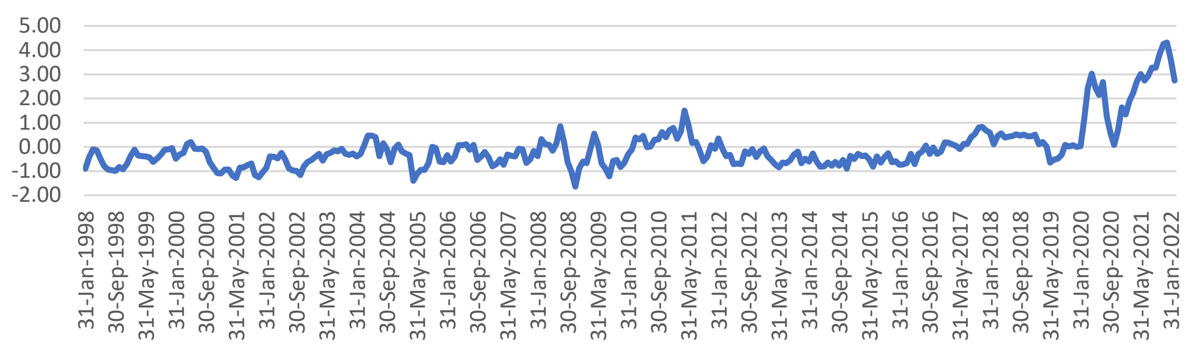
Section 2. Data

The data used in this study include inflation rate (*INF*), change in industrial production (ΔIND), change in WTI (West Texas Intermediate) crude oil price (ΔWTI), monetary policy uncertainty index (*MPU*) based on Baker, Bloom and Davis (2016), Global Supply Chain Pressure Index (*SupplyChain*), aggregate stock market return proxied by S&P500 return (*R_MKT*), and ten sectoral stock returns, including Basic Materials (R_BASM), Consumer Staples (R_CSTP), Energy (R_ENGY), Financials (R_FINL), Health Care (R_HLCA), Industrials (R_INDU), Real Estate (R_REIT), Technology (R_TECH), Telecommunication (R_TELE) and Utilities (R_UTIL).

The inflation data (*INF*) is calculated as month-to-month percentage change in CPI index obtained from the U.S. Bureau of Labor Statistics times 100. The monthly industrial production and WTI crude oil price are obtained from Federal Reserve Bank of St. Louis and the change is calculated as log difference of the variable times 100. Monetary Policy Uncertainty Index (*MPU*) is obtained from www.policyuncertainty.com and it follows Baker, Bloom and Davis (2016) methodology and uses hundreds of U.S. newspapers covered by Access World News.

The Global Supply Chain Pressure Index developed by Federal Reserve Bank of New York covers a number of different metrics.[4] It includes indicators of global transportation costs, such as Baltic Dry Index (cost of shipping raw materials), Harper Index (container shipping rate changes), outbound and inbound airfreight price indices. It also includes supply chain related components from Purchasing Managers' Index surveys that focus on manufacturing firms across seven inter-connected economies (China, Japan, South Korea, Taiwan, Euro Area, the U.S., and the U.K.). Since the index is only available after the end of 1997, our balanced sample goes from January 1998 to February 2022. A higher *GSCPI* indicates higher transportation cost and more delay in shipment while a lower *GSCPI* means lower transportation cost and more on-time shipment. Figure 1 shows GSCPI value over the whole sample period and it is obvious that there was the first major disruption in supply chain in April 2020 when most countries began to shut down their borders as the pandemic started to spread all over the world. In November 2021, the second wave of delta and omicron variants began to dominate and caused another round of major supply chain problem. *SupplyChain* measures increase or decrease of the Global Supply Chain Pressure Index.

Figure 1. Global Supply Chain Pressure Index (*GSCPI*)



Source: Federal Reserve Bank of New York

[4] https://www.newyorkfed.org/research/policy/gscpi#/overview

All stock returns are calculated as log difference of the stock indices times 100. The stock indices data are total return (*RI*) index from *Datastream*. The summary statistics of the aggregate and sectoral stock returns are reported in Table 1 Panel A. The average monthly returns range from 0.345% (Telecommunication) to 0.881% (Technology). The medians, on the other hand, range from 0.633% (Energy) to 1.595% (Technology). The Consumer Staples sector reveals the lowest volatility while Technology sector has the highest volatility. The Real Estate sector appears to be the most left skewed and has highest kurtosis.

Table 1 Summary statistics
Panel A: Descriptive Statistics for Sector indices

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
S&P500	0.684	1.242	12.525	-18.799	4.416	-0.806	4.771	69.30
Basic Materials	0.663	0.749	20.389	-28.825	6.537	-0.600	5.445	89.62
Consumer Staples	0.665	1.026	13.448	-13.130	3.734	-0.512	4.653	45.67
Energy	0.566	0.633	28.513	-45.502	6.898	-0.860	10.172	657.27
Financial	0.529	1.223	16.954	-24.055	5.807	-1.066	6.937	242.27
Health Care	0.754	1.277	12.821	-13.022	4.022	-0.571	3.846	24.41
Industrial	0.747	1.279	15.931	-22.608	5.468	-0.654	5.055	71.71
Real Estate	0.771	1.237	27.008	-35.851	5.826	-1.395	11.311	928.73
Technology	0.881	1.595	19.533	-32.333	7.377	-0.754	4.864	69.44
Telecommunication	0.345	0.988	27.492	-17.171	5.643	-0.153	4.952	47.16
Utilities	0.628	1.285	13.365	-13.657	4.463	-0.611	3.761	25.02

Notes: This table shows the descriptive statistics for the monthly S&P500 index return and ten sectoral stock returns from January 1998 to February 2022, with 290 observation numbers. Jarque-Bera test is a goodness-of-fit (chi-squared) test to see whether a variable's sample data has skewness and kurtosis matching a normal distribution. All stock index returns in this case do not have a normal distribution.

Panel B: Correlation between major variables

	INF	*ΔIND*	*R_MKT*	*MPU*	*SupplyChain*	*ΔWTI*
INF	1					
ΔIND	0.2036***	1				
	(0.0005)					
R_MKT	0.0574	0.2740***	1			
	(0.3299)	(0.0000)				
MPU	-0.0880	-0.1856***	-0.1715***	1		
	(0.1350)	(0.0015)	(0.0034)			
SupplyChain	0.0559	-0.2355***	0.1252**	0.0363	1	
	(0.3428)	(0.0001)	(0.0331)	(0.5383)		
ΔWTI	0.0829	0.4219***	0.2990***	-0.1454**	-0.0277	1
	(0.1592)	(0.0000)	(0.0000)	(0.0132)	(0.6380)	

Note: *INF* represents the month-to-month percentage change in CPI index (monthly inflation). *ΔIND* represents the monthly percentage change in industrial production. *R_MKT* represents the log difference of monthly S&P500 index. *MPU* represents the monetary policy uncertainty index based on Baker, Bloom and Davis (2016). *SupplyChain* represents the Global Supply Chain Pressure Index developed by Federal Reserve Bank of New York. ΔWTI represents the log difference of monthly WTI (West Texas Intermediate) crude oil price. Numbers in parentheses are p-values for whether the correlation coefficient is significantly different from zero.

To further investigate the relationship among the major variables in this study, a correlation matrix is generated, and p-values are reported to show whether these correlation coefficients are significantly different from zero. Table 2 Panel B shows that change in industrial production is correlated with all other major variables. It is positively correlated with inflation, stock market returns and change in oil price but negatively correlated with monetary policy uncertainty and supply chain pressure change. This suggests that the latter two factors may be risk factors that lead to the decline of industrial production. Stock market return is negatively correlated with monetary policy uncertainty, but positively correlated with supply chain pressure change. This may suggest that higher supply chain pressure is a sign of booming economies, therefore causing a positive correlation with stock market return.

Section 3. Methodology

The model used in this study includes three variables: inflation rate (*INF*), change in industrial production (ΔIND), and stock return (*R*) for the aggregate market or the ten sectoral measure. As the three endogenous variables could lead or lag each other, we put them in the order of inflation rate, change in industrial production and stock return. The basic VAR model is expressed as:

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots A_k Y_{t-k} + e_t \qquad (1)$$

Y_t is a vector [*INF*, ΔIND, *R*]' at month *t*, $A_1, A_2, \ldots A_k$ are 3xk vectors of coefficients for the lagged variables, e_t is a 3x1 vector error terms. The lag *k* for Y_t will be determined by various selection criteria. To analyze the existence of a causal relationship between the three variables, we apply the VAR Granger Causality/Block Exogeneity Wald tests, for which the null hypothesis states that there is no causal relationship between the variables. [5]

Then three potential exogenous variables are added to the VAR system to investigate the uncertainty factors from monetary policy, supply chain and oil price. The full VAR system can be rewritten as:

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots A_k Y_{t-k} + BX_t + e_t \qquad (2)$$

where X_t = [*MPU*, *SupplyChain,* ΔWTI]' at month *t*; *B* is a 1x3 vector of coefficients. *MPU* is expected to have a negative impact on industrial production growth and stock market return as higher monetary policy uncertainty tends to impede business investment. *SupplyChain* is expected to have a negative impact on industrial production growth due to the strain on inventory and supplies, but it could have a positive impact on stock returns as it is a signal for booming economic activities depending on the sectors. We use market return first for *R* and then replace it with ten sectoral returns to detect which sectors are most affected by supply chain pressure change. ΔWTI is expected to have a positive impact on all three endogenous variables as higher oil price usually indicates more demand and a booming global economy.

To further investigate the impact of *SupplyChain* on different sectoral stock returns during the Covid-19 pandemic period, we created a dummy variable *Crisis*, where *Crisis* = 1 during the

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[5] This procedure assesses the significance of each joint lagged endogenous variable in each equation of the VAR, through the χ^2 statistic, and simultaneously the significance of the joint contribution of all other endogenous variables.

months of March to May of 2020 and 0 otherwise. We then use the interaction term *Crisis*SupplyChain* to capture how supply constraints during the pandemic affected the industrial production and stock returns differently and Equation (2) can be rewritten as:

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots A_k Y_{t-k} + BX_t + C * Crisis_t + D * Crisis_t * SupplyChain_t + e_t \quad (3)$$

The coefficient D is expected to be negative given that the supply constraints slow down the economic activities and dampen the investor sentiment at the beginning of the pandemic.

Section 4. Empirical results

Subsection 4.1) Stationarity and lag determination

Before establishing the VAR model, we need to make sure all variables are stationary. An Augmented Dickey-Fuller test (Dickey and Fuller, 1979) is conducted and all variables are found to be stationary.[6] Then the lag of the VAR model based on Equation (1) is determined based on various criteria such as Akaike information criterion (AIC), Schwartz information criterion (SC), likelihood ratio test (LR), final prediction error (FPE) and Hannan-Quinn information criterion (HQ). All except SC have pointed to a 2-month lag as appropriate lag length for the VAR model.[7]

Subsection 4.2) Basic VAR model results without exogenous variables

Once the lag length is selected, Equation (1) is estimated using 2-month lag and the basic VAR model results are reported in Table 2. The data indicate that the lagged stock market return has a significantly positive effect on inflation and economic growth, while the 2-month lagged economic growth also has a significantly positive effect on stock market return. Not surprisingly, the positive relationship between nominal stock return and inflation is consistent with Fisher's hypothesis. A higher asset return has a wealth effect, which stimulates more spending and causes higher inflation (Geske and Roll, 1983). Since real output and real stock return have a positive relationship as suggested by Fama's proxy hypothesis, it also suggests a positive relationship between nominal output and nominal stock return.

Further test using Block Exogeneity Wald test shows that there is a two-way causality between economic growth and stock market return.[8] However, there is only one-way causality from economic growth and stock market return to inflation. This result is consistent with Pradhan, et al (2015) where economic growth and stock market development causes inflation both in short and long run with the "demand-following hypothesis", but not the other way around.

Table 2 VAR models without and with exogenous variables

	Basic VAR model			Full VAR model		
	INF	ΔIND	R_MKT	INF	ΔIND	R_MKT
INF(-1)	0.5239***	-13.6601	-93.3226	0.5226***	-8.7000	-66.0165
INF(-2)	-0.1863	25.5390	67.3459	-0.1752***	16.4122	73.9744
ΔIND(-1)	0.0002	0.1576**	-0.1945	0.0003*	0.1648***	-0.0534
ΔIND(-2)	0.0001	-0.1937***	0.5039**	0.0001	-0.1339***	0.5391***
R_MKT(-1)	0.0001***	0.0544***	0.0951	0.0002***	0.0394***	0.0222
R_MKT(-2)	0.0000	0.0312*	-0.0916	0.0000	0.0163	-0.1423***

[6] ADF test results are available upon request.
[7] The lag selection test results are available upon request.
[8] The results are available upon request. A nonlinear version of the Granger Causality test proposed by Hiemstra and Jones (1994) could be used given that the relationship among these variables could be nonlinear due to asymmetric shocks and crises. However, causality is not the focus of this paper and crises are considered in our later tests to account for some nonlinearity of the model.

C	0.0012***	-0.0096	0.6929**	0.0009***	0.0885	1.6111***
MPU				0.0000	-0.0011	-0.0116***
SupplyChain				0.0009***	-0.5894***	1.3768***
ΔWTI				0.0000*	0.0446***	0.1276***
R-squared	0.3207	0.1210	0.0311	0.3406	0.3132	0.1615
Adj. R^2	0.3062	0.1022	0.0104	0.3192	0.2909	0.1343

Note: INF represents month-to-month percentage change in CPI index (monthly inflation). ΔIND represents monthly percentage change in industrial production. R_MKT represents log difference of monthly S&P500 index. MPU represents monetary policy uncertainty index based on Baker, Bloom and Davis (2016). SupplyChain represents Global Supply Chain Pressure Index developed by the Federal Reserve Bank of New York. ΔWTI represents log difference of monthly WTI (West Texas Intermediate) crude oil price. The t-statistics are not reported due to limited space. The *t* critical values used are 2.60, 1.97 and 1.65 for 1%, 5% and 10% significance levels, respectively. ***, **, and * indicate significance at 1%, 5% and 10%, respectively. (-1) and (-2) indicate lag length of 1 month and 2 months respectively. The estimation of the basic VAR model is based on Equation (1).

Subsection 4.3) Full VAR model with exogenous variables

The full model from Equation (2) includes three important exogenous variables in the VAR system, namely monetary policy uncertainty (*MPU*), change in global supply chain pressure (*SupplyChain*) and change in oil price (ΔWTI). The full model results are shown in the right columns of Table 2. The coefficients for the endogenous variables remain consistent with the basic model. *MPU* has a significant and negative impact on stock market return, which suggests it is an uncertainty factor that affects investor behavior. However, it does not significantly impact the real economy, at least in the short run. This is consistent with studies such as Chiang (2020) that find significant negative impact from *MPU* to stock returns in the U.S. and spillover to other markets.[9]

On the other hand, *SupplyChain* has a negative impact on change in industrial production, but a positive impact on inflation and stock market return. This is consistent with the notion that supply chain pressure is tied to demand for goods and services so that higher supply chain pressure indicates higher aggregate demand and higher inflation, therefore better performance in the stock market, even though that puts more pressure on the growth in industrial production. The result is consistent with Calvolho, et al (2021) that supply chain pressure reduces the economic growth. What is different about our results is that this applies not only during natural disaster event, but during normal times as well. One unit change in the *GSCPI* on average causes a 0.59% decrease in industrial production. The finding on positive impact on inflation is also consistent with Giovanni, et al (2022) and LaBelle and Santacreu (2022) that supply chain disruptions pushes up inflation. Our finding applies to normal times in that one-unit change in the Index on average increases monthly inflation by 0.09%. The finding on the positive impact on stock return contradicts studies such as Ashraf (2020) and Latif et al (2021). But note that those studies are done during the Covid-19 period, which we will investigate further in Section 4.5) separately. This may suggest that moderate supply chain pressure is an indication of higher demand for products and services, which transfers to better earnings for companies and positive stock performance.

[9] Robustness check has been done to see whether fiscal policy uncertainty has a similar negative impact on stock return and the result is insignificant. The results are available upon request.

Change in *WTI* has a positive impact on all three variables in the VAR system, as it indicates higher demand in a booming economy and leads to higher inflation and asset returns. This result is consistent with Cologni and Manera (2008) and Wen et al (2021) in that change in oil price pushes up inflation. However, it contradicts Sadorsky (1999) and Jones et al (2004), which find that an increase in oil price decreases economic growth and real stock return. This may have to do with the use of nominal stock return and industrial production in this study.

Subsection 4.4) The impact of supply chain pressure change on sectoral stock returns

Baghersad and Zobel (2021) document that supply chain disruption has varying impact on different sized firms and different industry sectors, and the impact lasts not only in the short term but also over an extended period after the disruption occurs. Thus, in this section, we investigate how supply chain pressure change impacts sectoral stock returns differently. Some sectors are expected to be more sensitive to tight inventories and lack of supplies due to higher transportation costs. Each sectoral stock return replaces the market return in the VAR model and the results for all ten sectors are reported in ten panels of Table 3.

Table 3 VAR model with exogenous variables for sectoral stock returns

	INF	ΔIND	R_sector
Basic materials	0.0009***	-0.5885***	3.8890***
Consumer staples	0.0010**	-0.5347***	1.1399*
Energy	0.0009**	-0.5921***	1.3615
Financials	0.0009**	-0.5756***	1.4433
Health Care	0.0009**	-0.5498***	1.0296
Industrial	0.0009**	-0.5908***	1.6458**
Real Estate	0.0011***	-0.5795***	2.3667***
Technology	0.0008*	-0.6281***	1.0532
Telecommunications	0.0008**	-0.6159***	0.6143
Utilities	0.0009**	-0.5937***	0.7367

Note: Only results for *SupplyChain* are reported from each sector model. Ten sectors known as Basic materials, Consumer staples, Energy, Financials, Health Care, Industrials, Real estate, Technology, Telecommunications and Utilities are included. The other variables or notations are the same as noted in Table 1.

Not surprisingly, only Basic Materials, Consumer Staples, Industrials and Real Estate sectoral returns are significantly related to change in global supply chain pressure. These are the four sectors that rely on timely shipment of materials and supplies, and higher supply chain pressure is an indication that these sectors have high demand for materials and supplies, therefore statistically related to higher sectoral returns. The other sectors are mostly service-related and therefore are not heavily impacted by supply chain issue. The only exception is Energy sector, for which the transportation costs of energy products are mostly not included in the *GSCPI*. Our results are consistent with Baghersad and Zobel (2021), who find that firms from the transportation and utilities sectors suffer lower amount of loss than firms from the manufacturing and the mining sectors, because these essential service sectors are usually better prepared for supply chain disruptions or other natural disaster disruptions in the U.S. [10]

[10] The different results in China from He et al (2020) and Wang el al (2022) are worth further investigation in another study. One possible reason could be use of different industries in our study vs. the studies in China. We have tried to use alternative sub-industry data such as REITs, Pharmaceuticals, Biotech, Retail, Investment Services and

Subsection 4.5) The influence of Covid-19 pandemic on the relationship between supply chain and others

As the Covid-19 pandemic hit all countries around the world, the supply chain pressure suddenly increased due to shutdown of cities and factories in many countries, especially in China. Equation (3) is estimated with the aggregate market return and ten sectoral returns and only results for the added crisis variables are reported in Table 4 due to limited space and similar results for other variables. The *Crisis* dummy variable is significantly positive for all sectors except for energy and financials sectors in the equation of Δ*IND* and in the equation of stock return, which suggests that even though the pandemic seemed to affect the business activities and stock market returns in March to May 2020, the industrial production and stock returns maintained upward trend in the three months after. However, the interaction term *Crisis*SupplyChain* is significantly negative for all sectors in the equation of Δ*IND* and in the equation of stock return and is marginally significant for a few sectors in the equation of inflation. This suggests that during the pandemic, the negative relationship between *SupplyChain* and Δ*IND* is intensified while the positive relationship between *SupplyChain* and stock return gets weaker. There are structural changes in the relation between *SupplyChain* and stock return during the pandemic, which could explain the conflicting results from this paper compared to Ashraf (2020) and Latif et al (2021).

Table 4 VAR model with crisis dummy

	INF	ΔIND	R
S&P500			
Crisis	-0.0012	3.4139***	13.9143***
Crisis*SupplyChain	-0.0032	-9.7275***	-15.2340***
Basic Materials			
Crisis	-0.0012	3.5547***	12.8585**
Crisis*SupplyChain	-0.0036	-9.6674***	-15.7649***
Consumer Staples			
Crisis	-0.0005	3.6225***	6.8042*
Crisis*SupplyChain	-0.0035	-9.6216***	-9.1639**
Energy			
Crisis	-0.0002	3.9158***	2.9898
Crisis*SupplyChain	-0.0022	-9.7644***	-24.0910***
Financials			
Crisis	0.0001	3.7219***	7.5242
Crisis*SupplyChain	-0.0044*	-9.8449***	-17.0935***
Health care			
Crisis	-0.0009	3.4138***	11.8025***
Crisis*SupplyChain	-0.0033	-9.4839***	-10.6732***
Industrials			
Crisis	-0.0006	3.5733***	15.2086***
Crisis*SupplyChain	-0.0041*	-9.8338***	-19.2325***
Real Estate			

Banking data. The results are mostly similar to those with the sector data used. The results can be available unpon request due to space limit. Another possible reason could be due to better preparation of U.S. disaster management system.

Crisis	0.0001	3.6859***	10.7261**
Crisis*SupplyChain	-0.0049**	-9.8822***	-19.2724***
Technology			
Crisis	-0.0005	3.3202***	21.0936***
Crisis*SupplyChain	-0.0035	-9.6695***	-15.8160***
Telecommunications			
Crisis	-0.0001	3.6020***	11.5989**
Crisis*SupplyChain	-0.0044*	-9.6842***	-11.6881**
Utilities			
Crisis	-0.0004	3.5866***	8.0230*
Crisis*SupplyChain	-0.0037	-9.6137***	-9.2374**

Note: ***, ** and * indicate significance of t statistics at 1%, 5% and 10% respectively. Due to limited space, only the results on the added crisis variables are reported. However, full results are available upon request.

Section 5. Conclusion

The supply chain issue has attracted much attention during the pandemic due to measures adopted such as restrictions in transportation facilities, border closure and shutdown of factories and cities. This study examines the relationship between change in supply chain pressure and inflation, change in industrial output and aggregate/sectoral stock returns, and the structural change of the relationship during the pandemic.

For the whole sample period from January 1998 to February 2022, change in supply chain pressure has a positive relation with inflation and aggregate stock return and a negative relation with change in industrial output. The few sectoral returns that have a positive relationship with supply chain pressure change are Basic materials, Consumer staples, Industrials, and Real estate. When considering the most difficult times of the pandemic in March to May of 2020, change in supply chain pressure has a significant and negative impact on industrial output and stock return. Contrary to what most think, it does not significantly increase the inflation during those three months. This could be due to the inventory stock businesses still have during those few months and lower demand from consumers during the lock down.

The monetary policy uncertainty affects the aggregate market return negatively, consistent with the literature. However, it only affects a few sectoral returns such as Financials, Industrials, Technology, and Utilities. Oil price shocks affect all variables in the VAR system (inflation, industrial output, stock returns) positively.

This study provides some policy implications to the policy makers. To ease inflation, governments may want to reduce supply chain pressure by providing better port management and favorable policies towards food industries in the short term. In the long run, industrial policies should be considered to keep at least some production capacity of important basic materials and industrial products (such as chips) at home to mitigate the disruption of production due to supply chain issues.

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