Finance Research Letters 58 (2023) 104495

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

Commodity price shocks, supply chain disruptions and U.S. inflation[☆]

Elena Maria Diaz [a,*], Juncal Cunado [b], Fernando Perez de Gracia [b]

[a] *Universidad Pontificia Comillas, Alberto Aguilera 23, Madrid, 28015, Spain*
[b] *Universidad de Navarra, Spain*

ARTICLE INFO

JEL classification:
E32
E37
F47
F62

Keywords:
Cost-push commodity factor
Supply chain disruptions
Inflation
Structural VAR

ABSTRACT

This paper analyzes the impact of commodity price shocks and global supply chain disruptions on U.S. inflation rates. Based on the idea that the inflationary effect of particular commodities is time-varying, our main contribution is to construct a Cost-Push Commodity (CPC) factor through a genetic algorithm which allows to recursively select the combination of commodity prices that best explain U.S. inflation over time. When this factor is included into a Structural Vector Autoregressive (SVAR) model, average and time-varying impulse response functions show how the U.S. inflation rate has responded to commodity price shocks and supply chain disruptions over the sample period, including the crisis caused by the COVID-19 pandemic. Important policy implications can be derived from these results.

1. Introduction

In the aftermath of the COVID-19 pandemic, exacerbated inflation threatened the stability of the global and domestic economies. In the U.S., inflation increased from 1.23% in year 2020 to 4.70% in 2021, far beyond the targeted level of 2%. This sharp increase in prices has been mainly attributed to exogenous shocks; in particular, to disruptions in the global supply chain (i.e., Benigno et al., 2022; di Giovanni et al., 2022; Guerrieri et al., 2022) and to increases in commodity prices (i.e., Kilian and Zhou, 2022; Peersman, 2022). The objective of this paper is to estimate the effects of these exogenous shocks, i.e., global supply chain disruptions and commodity price shocks, on U.S. inflation, and to examine their persistence.

Different approaches have been taken in the literature to measure global supply disruptions. In a recent study, Benigno et al. (2022), propose a new indicator, the Global Supply Chain Pressure (GSCP), based on several cross-country and global indicators of supply chain pressures. A different methodology is used by Kilian et al. (2023) who construct the North American Container Trade index (NACTI), based on the volume of container trade to and from North America. The authors develop an SVAR model that measures the effect of domestic and foreign demand shocks on international trade, defining all remaining shifts in trade as global supply chain disruptions. In this paper, we extend the model by Kilian et al. (2023) with a commodity factor to disentangle changes in price levels caused by shifts in aggregate demand, termed demand-pull inflation, from those caused by changes in production costs, denominated cost-push inflation.

☆ We thank the editor, Samuel Vigne, and two anonymous referees for their valuable comments and suggestions. We also thank Fredj Jawadi, Michał Rubaszek and the participants at the XVII Conference of the Spanish Association for Energy Economics and the 6th International Workshop on Financial Markets and Nonlinear Dynamics for their helpful comments. We also thank Lutz Kilian for providing access to the North-American container trade data. The authors gratefully acknowledge financial support by the Grant PID2020-114275GB-I00 funded by MCIN/AEI/10.13039/501100011033.

* Corresponding author.
E-mail addresses: emdaguiluz@comillas.edu (E.M. Diaz), jcunado@unav.edu (J. Cunado), fgracia@unav.edu (F. Perez de Gracia).

https://doi.org/10.1016/j.frl.2023.104495
Received 19 July 2023; Received in revised form 24 August 2023; Accepted 18 September 2023
Available online 20 September 2023
1544-6123/

Most of the literature examining the cost-push effect of commodity prices on inflation has focused on oil price shocks (i.e., Hooker, 2002; Kilian, 2009; Baumeister and Peersman, 2013; Baumeister and Kilian, 2016; Gelos and Ustyugova, 2017; Kilian, 2019). Fewer research has examined the inflationary effects of other commodity prices (i.e., Chen et al., 2014; Furceri et al., 2015; Garratt and Petrella, 2022). However, the commodity price factor we introduce into the SVAR model is a weighted average of the prices of all cost-push commodities. We denominate this the Cost-Push Commodity (CPC) factor and consider that the inflationary effect of particular commodities is time-varying. We implement the method proposed by Diaz and Perez-Quiros (2021) for the selection of commodities through a genetic algorithm, and adopt their approach by setting the algorithm to select the commodities that best explain U.S. inflation, controlling for aggregate demand and global supply disruptions.

Four are the main contributions of this paper. First, we extend the model by Kilian et al. (2023) with the commodity price factor and U.S. inflation. Second, while most of the above literature seeks to explain recent inflation increases, this paper considers a longer time span, from 1995 to 2021, covering different episodes of high inflation rates. Third, we construct a CPC factor that considers the time-varying inflationary effect of each commodity. Finally, we examine the interaction between commodity prices and supply chain disruptions and determine their relative importance in explaining U.S. inflation during different periods.

The remainder of the paper is structured as follows. Section 2 estimates the CPC factor, Section 3 presents the SVAR model and the main results. Finally, Section 4 concludes.

2. Estimation of the cost-push commodity factor

Following Diaz and Perez-Quiros (2021), we define the CPC factor, f_t, through the following factor model:

$$x_{it} = \lambda_i f_t + e_{it} \quad \forall\, i \,\exists\, \{1, \dots, n_s\} \tag{1}$$

where x_{it} is the log-level of the real price of commodity i at time t, λ_i is a loading factor, e_{it} is an error term, and n_s is the total number of commodities selected as determinants of U.S. inflation. Eq. (1) is estimated using Principal Component Analysis (PCA), where f_t is the first principal component.

For the selection of commodities, as in Diaz and Perez-Quiros (2021), we begin by defining A_q as a binary vector of size $1 \times n$, where n is the total number of all available commodity price series, such that

$$A_q = (a_{1q}, a_{2q}, \dots, a_n) \tag{2}$$

whose elements a_{iq} take the value 1 when commodity i is selected for the estimation of the CPC factor, and 0, otherwise. The commodity factor, f_q, is, therefore, a function of A_q, such that $f_q(A_q)$, estimated as the first principal component of the selected commodities.

We then define inflation π_t as a function of the $p = 12$ lags of y_{qt}, which is a vector containing U.S. real consumption ($usrpc$), U.S. manufacturing industrial production ($usipm$), $f_{qt}(A_q)$, NACTI, and inflation, such that

$$\pi_t = \mu + \sum_{j=1}^{p} \theta_j y_{qt-j} + \epsilon_t \tag{3}$$

Eq. (3) is estimated through Ordinary Least Squares (OLS) and the optimization problem is defined as

$$\min_{A_q} \quad \sum_t \epsilon_t^2(A_q) \tag{4}$$

where we minimize the sum of squared errors resulting from the estimation of Eq. (3), by selecting A_q.

Following Diaz and Perez-Quiros (2021), we solve this optimization problem through the use of the genetic algorithm (Holland, 1975), and define the solution as A^*. Diaz and Perez-Quiros (2021) provide a full description of the procedure.

We perform a recursive estimation of the CPC factor, in which the genetic algorithm is set to search for A^* with the information available up to time t (I_t), such that f_t is a function of $(A_t^* \mid I_t)$. We use data starting in January 1995, and perform the recursive estimation from January 2005 until March 2021.

There is a total of $n = 56$ commodity price series, made available by the World Bank, including energy commodities, metals, raw materials and agricultural products. Prices are deflated with the U.S. consumer price index (CPI), as commodities are globally traded in U.S. dollars. Data for U.S. personal consumption, and U.S. manufacturing industrial production are obtained from the St. Louis Federal Reserve. These are also deflated by the U.S. CPI and log-linearly detrended. The NACTI (Kilian et al., 2023) was made available by the authors, and inflation is defined as the year-to-year percent change of the U.S. CPI.

Fig. 1 shows the recursively estimated CPC factor along with U.S. inflation. We can observe a clear long-run relationship between the CPC factor and changes in price levels. We first observe an important decrease of the CPC factor in the end of the 1990s, when commodity prices fell to its lowest level in four years due to the Asian economic crisis. This construed a deflationary pressure, which only partly transmitted to U.S. inflation, as the domestic economy remained resilient to the foreign crisis. This is then reverted, as the Asian economy recovers in the first years of the 2000s, generating inflationary pressures signaled by an increase of the CPC factor until the breakout of the 2001 recession.

Note that while, during the in-sample period of estimation (1995M1 to 2004M12), the factor closely mimics the fluctuations of U.S. inflation, this is followed by a period of high volatility in the CPC factor that begins in 2005 and ends with the breakout of the Global Financial Crisis (GFC).

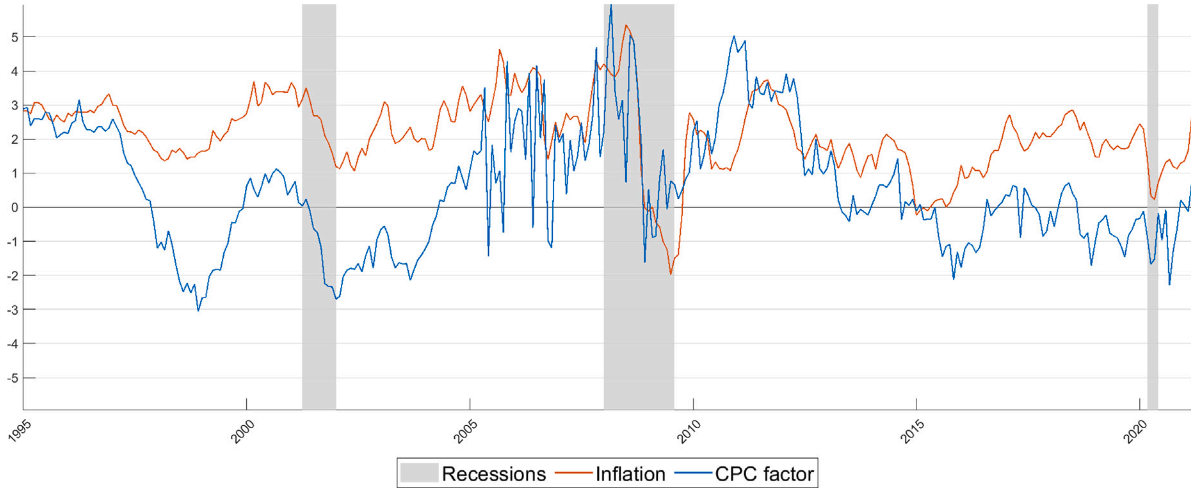


Fig. 1. CPC factor and U.S. inflation.
Notes: The figure above shows the recursively estimated CPC factor and U.S. year-to-year inflation at a monthly frequency. NBER-dated recessions are presented in light gray.

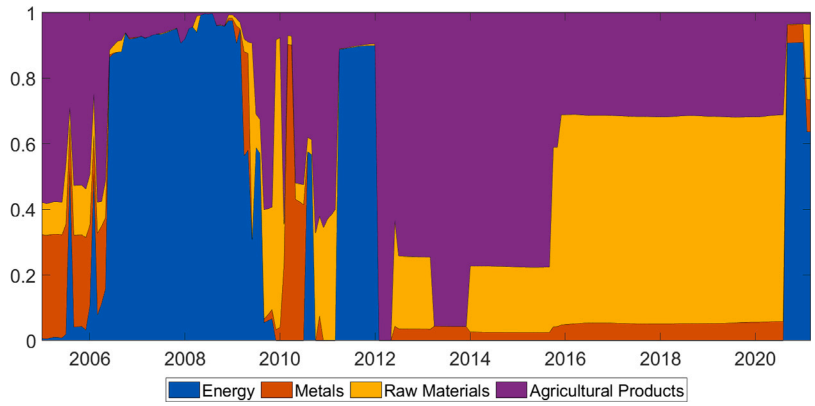


Fig. 2. Weights given to each commodity type.
Notes: The figure above shows the time-varying weights given to the commodities belonging to the following groups: energy, metals, raw materials, and agricultural commodities.

After the GFC, however, the CPC factor stabilizes throughout the remainder of the sample period and has a contemporaneous relationship with inflation. As demand fell in the aftermath of the financial crisis, so did commodity prices and inflation. More importantly, following the recovery, we can observe a high correlation between the CPC factor and U.S. inflation until the end of the sample.

We now examine which are the commodities that have induced cost-push inflation in the U.S. during the recursively estimated sample period, presenting the aggregated weights assigned to each commodity type. These are defined in the following way:

$$\begin{aligned} \lambda_{t,E}^2 &= \sum_i \lambda_{t,i}^2 \quad \forall\, i \,\exists\, \Omega_E \\ \lambda_{t,M}^2 &= \sum_i \lambda_{t,i}^2 \quad \forall\, i \,\exists\, \Omega_M \\ \lambda_{t,R}^2 &= \sum_i \lambda_{t,i}^2 \quad \forall\, i \,\exists\, \Omega_R \\ \lambda_{t,A}^2 &= \sum_i \lambda_{t,i}^2 \quad \forall\, i \,\exists\, \Omega_A \end{aligned} \tag{5}$$

where $\lambda_{t,E}^2$, $\lambda_{t,M}^2$, $\lambda_{t,I}^2$, and $\lambda_{t,A}^2$ are the aggregated weights assigned at period t to energy commodities, metals, raw industrial commodities and agricultural commodities, respectively, and $\lambda_{t,i}$ is defined as in Eq. (1).

Fig. 2 shows that the cost-push commodities have varied significantly in the past two decades. Energy commodities played a prominent role during 2006–2009, in 2012, and 2020, while agricultural products and raw materials were the main determinants

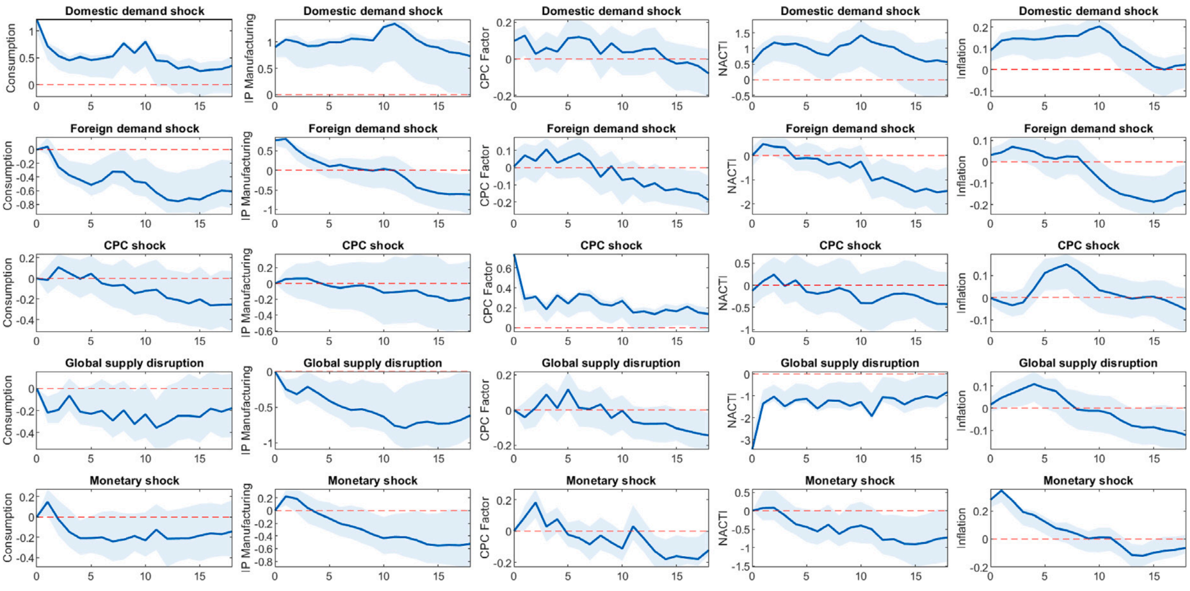


Fig. 3. Impulse response functions: Full sample.Notes: The figure above shows the impulse response functions (IRFs) with a 95% confidence interval.

of the CPC factor during 2012–2014 and 2014–2020, respectively. The results suggest, thus, that there is a high cost-push effect of energy prices during the commodity boom, the GFC, the Euro Sovereign Debt Crisis, as well as the COVID-19 pandemic. The remaining periods, where the CPC factor denotes mainly deflationary pressures (Fig. 1), weights are concentrated on agricultural products and on raw industrial materials. Little weight is given to metal prices for the study period.

3. A structural model for U.S. inflation

We now examine the effect of global supply disruptions and cost-push commodity shocks on U.S. inflation. Let $y_t = [usrpc_t, usipm_t, f_t, NACTI_t, \pi_t]$ be generated by a covariance stationary structural VAR(12) process of the form $B_0 y_t = B_1 y_{t-1} + \cdots + B_{12} y_{t-12} + w_t$. The reduced-form errors may be written as $\mu_t = B_0^{-1} w_t$, where B_0^{-1} denotes the structural impact multiplier matrix. In the spirit of Kilian et al. (2023), the structural shocks are identified as follows:

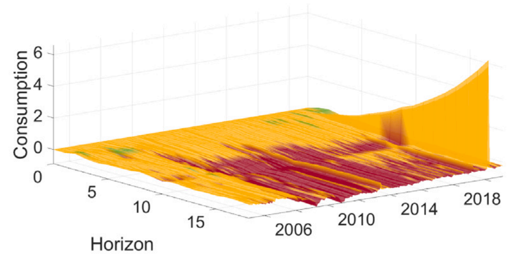
$$\begin{pmatrix} \varepsilon_t^{usrpc} \\ \varepsilon_t^{usipm} \\ \varepsilon_t^{f} \\ \varepsilon_t^{NACTI} \\ \varepsilon_t^{\pi} \end{pmatrix} = \begin{bmatrix} b_{11}^0 & 0 & 0 & 0 & 0 \\ b_{21}^0 & b_{22}^0 & 0 & 0 & 0 \\ b_{31}^0 & b_{32}^0 & b_{33}^0 & 0 & 0 \\ b_{41}^0 & b_{42}^0 & b_{43}^0 & b_{44}^0 & 0 \\ b_{51}^0 & b_{52}^0 & b_{53}^0 & b_{54}^0 & b_{55}^0 \end{bmatrix} * \begin{pmatrix} \omega_t^{domestic\ demand} \\ \omega_t^{foreign\ demand\ of\ man.\ goods} \\ \omega_t^{cost-push\ commodity\ shock} \\ \omega_t^{global\ supply\ disruption} \\ \omega_t^{monetary\ shock} \end{pmatrix} \tag{6}$$

Fig. 3 shows the impulse response functions (IRFs), where f_t corresponds to the recursively estimated CPC factor. These show the response of each variable to a one standard deviation shock, with the exception of the impulse response functions of global supply disruptions, which show the effect of a negative standard deviation, given that such disruptions would consist in a decrease in international trade.

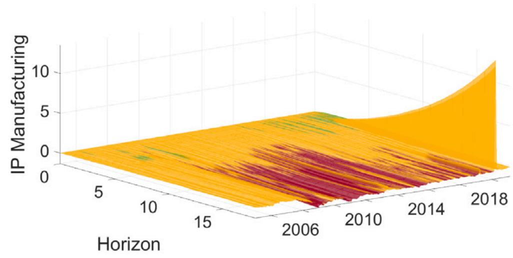
As can be observed in Fig. 3, a cost-push commodity shock shows a transitory, yet significant and positive effect on inflation between half a year and a year after the occurrence of the shock. There are no significant effects on personal consumption, manufacturing activity, or trade, although results suggest a negative effect on domestic demand in the long run. Such results clearly denote the nature of the CPC factor as a commodity supply index, as opposed to a global economic activity indicator (i.e., Kilian, 2009, 2019; Alquist et al., 2020; Diaz and Perez-Quiros, 2021; Delle Chiaie et al., 2022).

Moreover, global supply chain disruptions have a negative transitory effect on domestic demand, a permanent negative effect on manufacturing activity, and a transitory inflationary effect that lasts for half a year, both on commodity prices as well as on consumer prices.

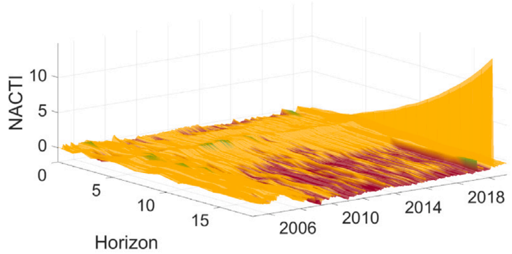
Furthermore, to examine time variation in the transmission mechanism of the shocks, we also recursively estimate the impulse response functions, where the CPC factor at time t is $f_t(A_t^* \mid I_t)$. Fig. 4 shows the time-varying IRFs for cost-push commodity shocks and global supply disruptions from January 2005 to March 2021. Note that since the breakout of the GFC, we observe a significant long-term negative effect of CPC shocks on personal consumption and manufacturing activity following half a year after the shock, and on trade following a year of the shock. The effect on inflation, however, is positive and transitory in nature, being significant immediately after the occurrence of the shock, and dying out after a year.



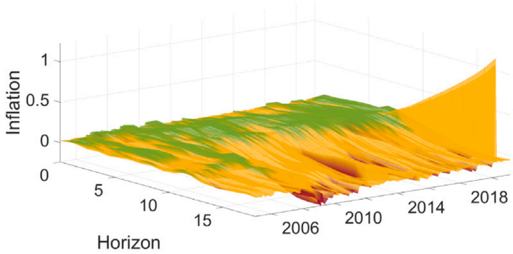
(a) Effect of a CPC shock on consumption



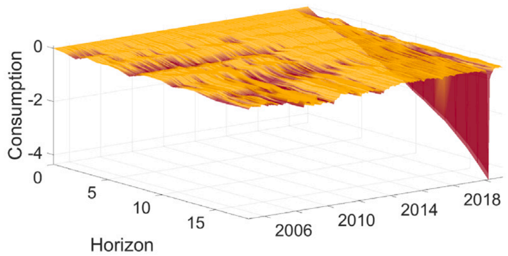
(b) Effect of a CPC shock on manufacturing



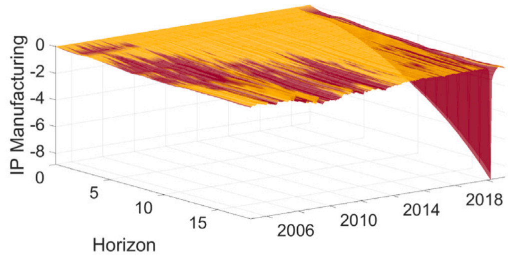
(c) Effect of a CPC shock on international trade



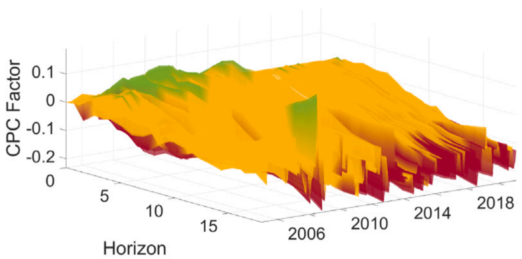
(d) Effect of a CPC shock on inflation



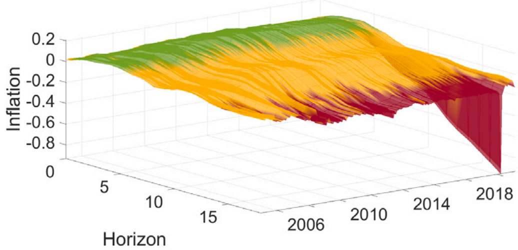
(e) Effect of a global supply disruption on consumption



(f) Effect of a global supply disruption on manufacturing



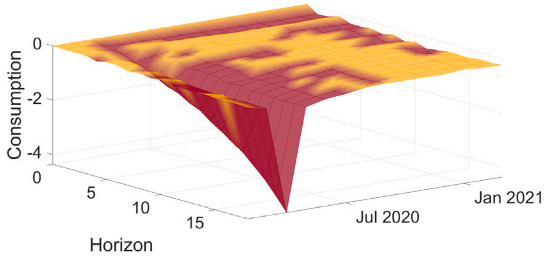
(g) Effect of a global supply disruption on the CPC factor



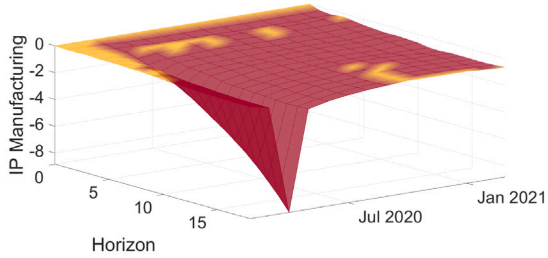
(h) Effect of a global supply disruption on inflation

Fig. 4. Time-varying impulse response functions.
Notes: The figure above shows the recursively estimated impulse response functions (IRFs) for each shock. Green values denote a significantly positive response within a 95% confidence interval. Red values denote a significantly negative response within a 95% confidence interval. Yellow values denote insignificant values within a 95% confidence interval. x-axis: months after shock; y-axis: magnitude of response; z-axis: sample date.

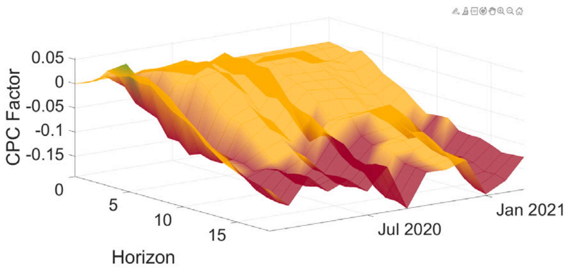
Moreover, global supply disruptions significantly increased commodity prices during the commodity boom until the GFC. However, the effect of global supply disruptions on U.S. inflation is stable throughout most of the sample, generating a transitory inflationary pressure for a half year, but a deflationary pressure in the long-term as it depresses demand. This was, nevertheless, quite more significant during the COVID-19 crisis. A close-up of the effects of global supply disruptions and CPC shocks are presented in Figs. 5 and 6. Results suggest that during the COVID-19 pandemic, inflation rates were more affected by global supply disruptions than by commodity price shocks in the breakout of the pandemic, but disruptions in commodity markets resulted in higher inflation during the recovery.



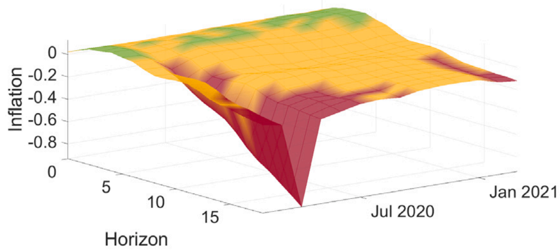
(a) Effect on consumption



(b) Effect on manufacturing

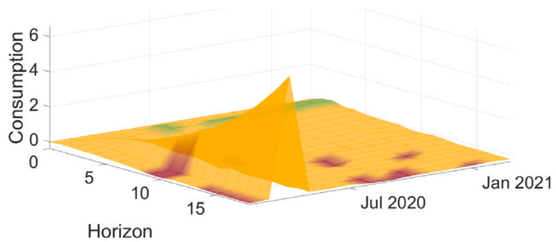


(c) Effect on the CPC factor

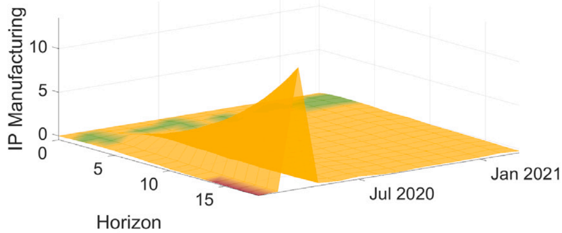


(d) Effect on inflation

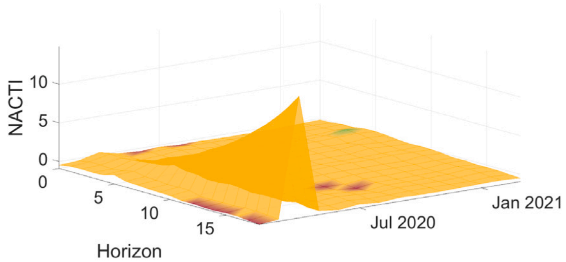
Fig. 5. Effect of global supply disruptions during the COVID-19 pandemic.
Notes: The figure above shows the recursively estimated impulse response functions (IRFs) for global supply disruptions from February 2020 to March 2021. Green values denote a significantly positive response within a 95% confidence interval. Red values denote a significantly negative response within a 95% confidence interval. Yellow values denote insignificant values within a 95% confidence interval. x-axis: months after shock; y-axis: magnitude of response; z-axis: sample date.



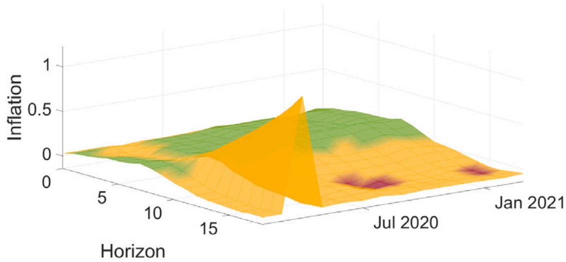
(a) Effect on consumption



(b) Effect on manufacturing



(c) Effect on trade



(d) Effect on inflation

Fig. 6. Effect of CPC shocks during the COVID-19 pandemic.
Notes: The figure above shows the recursively estimated impulse response functions (IRFs) for CPC shocks from February 2020 to March 2021. Green values denote a significantly positive response within a 95% confidence interval. Red values denote a significantly negative response within a 95% confidence interval. Yellow values denote insignificant values within a 95% confidence interval. x-axis: months after shock; y-axis: magnitude of response; z-axis: sample date.

4. Conclusions

This paper examines the impact of global supply chain disruptions and commodity price shocks on U.S. inflation by extending the SVAR model by Kilian et al. (2023) with a CPC factor and the U.S. inflation rate.

The CPC factor shows a clear long-run relationship with U.S. inflation and helps identify those periods in which inflation is mainly supply-driven. Furthermore, this factor suggests that cost-push commodities have varied significantly in the past two decades, revealing the importance of each commodity in explaining U.S. inflation. Moreover, the results suggest that U.S. inflation is significantly affected by both shocks to the CPC factor and supply chain disruptions. Our results extend previous studies that are consistent with the theory that exogenous shocks tend to pass-through inflation rates, in the spirit of Benigno et al. (2022) and Kilian and Zhou (2022).

Our results assist policymakers in understanding the extent to which inflation rates are explained either by supply or demand factors. Since monetary policy works through demand channels, supply-driven inflation requires the use of other measures. High inflation due to supply chain disruptions or a particular set of commodities, calls for the strategic management of inventories and reserves, as well as for investments aimed at increasing the economy's resilience to external shocks. In particular, the increased weight of fossil fuel prices in the CPC factor creates incentives for authorities to accelerate the energy transition.

This research could be extended in the future to include recent geopolitical events, such as Russia's invasion of Ukraine, or distinguishing between headline and core U.S. inflation rates.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Alquist, R., Bhattarai, S., Coibion, O., 2020. Commodity-price comovement and global economic activity. J. Monetary Econ. 112, 41–56.
Baumeister, C., Kilian, L., 2016. Lower oil prices and the U.S. Economy: Is this time different? Brook. Pap. Econ. Act. 287–336.
Baumeister, C., Peersman, G., 2013. Time-varying effects of oil supply shocks on the U.S. economy. Am. Econ. J.: Macroecon. 5 (4), 1–28.
Benigno, G., di Giovanni, J., Groen, J.J., Noble, A.I., 2022. The GSCPI: A new barometer of global supply chain pressures. Federal Reserve Bank New York Staff Pap. (1017).
Chen, Y.C., Turnovsky, S.J., Zivot, E., 2014. Forecasting inflation using commodity price aggregates. J. Econometrics 183 (1), 117–134.
Delle Chiaie, S., Ferrara, L., Giannone, D., 2022. Common factors of commodity prices. J. Appl. Econometrics 37 (3), 461–476.
di Giovanni, J., Kalemli-Ozcan, S., Silva, A., Yildirim, M.A., 2022. Global Supply Chain Pressures, International Trade, and Inflation. Working Paper 30240, National Bureau of Economic Research.
Diaz, E.M., Perez-Quiros, G., 2021. GEA tracker: A daily indicator of global economic activity. J. Int. Money Finance 115, 102400.
Furceri, D., Loungani, P., Simon, J., Wachter, S., 2015. Global Food Prices and Domestic Inflation: Some Cross-Country Evidence. Working Paper 2015/133, International Monetary Fund.
Garratt, A., Petrella, I., 2022. Commodity prices and inflation risk. J. Appl. Econometrics 37 (2), 392–414.
Gelos, G., Ustyugova, Y., 2017. Inflation responses to commodity price shocks. How and why do countries differ? J. Int. Money Finance 72, 28–47.
Guerrieri, V., Lorenzoni, G., Straub, L., Werning, I., 2022. Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages? Amer. Econ. Rev. 112 (5), 1437–1474.
Holland, J.H., 1975. Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence. University of Michigan Press.
Hooker, M.A., 2002. Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. J. Money Credit Bank. 34 (2), 540–561.
Kilian, L., 2009. Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. Amer. Econ. Rev. 99 (3), 1053–1069.
Kilian, L., 2019. Measuring global real economic activity: Do recent critiques hold up to scrutiny? Econom. Lett. 178, 106–110.
Kilian, L., Nomikos, N., Zhou, X., 2023. Container trade and the U.S. recovery. Int. J. Central Bank. (forthcoming).
Kilian, L., Zhou, X., 2022. The impact of rising oil prices on U.S. inflation and inflation expectations in 2020. Energy Econ. 113, 106228.
Peersman, G., 2022. International food commodity prices and missing (dis)inflation in the euro area. Rev. Econ. Stat. 104 (1), 85–100.