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The Real Meaning of the Fed Information Shocks: Good and Bad News for Europe

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The real meaning of the Fed information shocks: good and bad news for Europe

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PRELIMINARY AND INCOMPLETE

Abstract

The Fed information shocks play a distinct role in transmitting the central bank's policies across borders, although their real economic meaning has been largely overlooked. I study through a panel local projection model how heterogeneity in euro area industries' trade exposure vis-à-vis the US influences how the industries experience the information shock. In doing so I lean on the theoretical work of the production network literature and account for input-output linkages that are decisive for the predictions of the shock's international influence, hidden in the aggregate response. The results reveal that the Fed information shocks identified from high-frequency financial data extend to real economic effects across the Atlantic, yet the impact depends crucially on the trade partner's exposure to the US economy. The results are not solely attributable to the expenditure-switching effects of the exchange rate nor financial channels. From a European perspective, the Fed information shocks appear as a US demand shock similar to the effects US macroeconomic news releases, while a 'pure' US monetary policy bears essentially no significance for euro area production.

1 Introduction

This paper examines the real economic impact of the central bank information effects at the international level, namely the potential of the US Federal Reserve to affect European economic activity through its 'information shocks' about the US economic outlook. The paper brings forth new evidence that the Fed information shocks represent potent demand shocks for the (ultimate) trade partners of the US, the euro area. It is not obvious that the Fed information shocks could yield real economic effects in low frequency macroeconomic data, given that the most standard identification strategy of the shocks (and the one addressed in this paper) distils them from high-frequency financial data and relies on rather strong assumptions on the public's ability to process the central bank signals appropriately for asset valuation. The central bank information effects are often receiving research interest that is secondary to the effects of 'pure monetary shocks', and the central bank information shocks are commonly treated as a "catch all" concept for any monetary policy surprises that generate a counterintuitive public reaction according to standard monetary models. Hence the economic meaning of the central bank information shocks as distinct demand shocks is generally overlooked in the existing literature. This paper sets out to study the economic significance of these shocks from an international, real economic standpoint. In doing so it resorts to the methodology of the production network literature to disentangle the international input-output linkages that generate an ambiguous impact for a given demand shock, and applies the production network measures in an empirical model that interacts the network measures with the Fed information shocks.

Externally identified monetary policy shocks have become part of the standard toolkit of empirical macroeconomists studying the effects of monetary policy onto the economy, a topic that is evergreen in macroeconomics (e.g. in SVAR-IV of Mertens and Ravn (2013), Stock and Watson (2012) and Stock and Watson (2018)). The external identification approach relies on measuring outside the empirical model high-frequency movements in interest rates representing unexpected policy changes and taking these as representative of exogenous variation in monetary policy in an event study manner. By now, a vast strand of the empirical monetary policy literature acknowledges that the commonly used high-frequency identified (HFI) monetary 'shocks' may be confounded with other economic forces that systematically coincide with monetary policy action, such as macroeconomic news introduced to the public simultaneously with monetary policy action. There are competing theories on the nature of these confounding forces, and among these a long-standing one is the 'central bank information channel' through which the central bank emits economic surprises to the public, not as monetary policy stance surprises but as information releases of the state of the economy. The theory goes that the macroeconomic information is introduced to the public simultaneously with monetary policy action, thus systematically fitting into the same time window with the policy announcements.

This paper addresses the theorised nature of these shocks by asking: do these 'other-than-pure-monetary-policy' shocks have a real economic meaning? Thus, the paper investigates from an international real economic viewpoint, whether the demand shock type implied by the shock classification scheme is consistent with how the economy will develop, i.e. whether the Fed information shock materialises in a consistent way with its identification assumptions. In macroeconomic terms, if there exists a central bank information channel, the ensuing real economic outcomes should be distinct from the effects predicated by pure monetary shocks as the information shock should represent a demand shock that has the opposite sign. The international production network aspect is taken in order to attain a comprehensive measure of trade exposure. The analysis then utilises the one-sided exposure that certain foreign trade partners have to the shock, which for them either represents changes in the demand for their output or changes in the demand for their inputs, depending on which side their trade exposure is. When the shock stirs both types of effects via input-output linkages (as typically is the case for a domestic industry) it is difficult to distill a clear response.

Thus, the paper takes a new approach with respect to the existing literature on the central bank information channel as it assesses the real economic effects of central bank policies from the response of trade partners' activity. Studying the effects of Fed information shocks through real economic variables such as industrial production are of interest in their own right, and they have the advantage over financial variables that real economic variables ought not to be prone to sentiments. I compute the EA industry's export and import exposures to the US resorting to the production network literature's measures of backward and forward participation that give a comprehensive summary of the trade exposure, as these measures account for both direct and indirect trade links with the US. In doing so, I will make use of the world input-output tables that allow us to discern the trade partners' input-output linkages vis-à-vis the US that may produce an ambiguous effect on firm performance for a given demand shock. The main advantage of using industry-level data on real economic activity from a major economic region like the euro area is the heterogeneity in global value chain participation of industries. This heterogeneity brings the necessary cross-sectional variation in the forward and backward participation of EA industries with respect to the US, which allows testing the Fed information shock as a distinct demand shock, since in theory the input-output linkages lead to a heterogeneous response to a given US demand shock.

For the empirical analysis of this paper I take the standard series of the Fed information shocks used in the literature, the shocks of Jarocinski and Karadi (2020) disentangled from pure monetary shocks through high-frequency financial data on the stock markets' response. The identification strategy relies crucially on the ability of the stock markets to interpret the Fed announcements and translate them into equity valuation that accurately corresponds to the state of the US economy. The aim is to test whether the central bank information channel can have systematic real economic effects, in line with the presumed nature of the demand shock as interpreted from stock price movements. The results of this paper reveal that the Fed information shocks identified in this way stir a significant response in a European industry's production, and the sign of the response is determined by the industry's exposure to the US economy; forward participating

European industries are boosted by the Fed information shock that simultaneously harms backward participating European industries. Therefore, the response of the ultimate EA exporters to the US, distinct from that of ultimate EA importers, suggests that the Fed information shocks are consistent with a distinct sign of demand in the US economy for foreign goods and goes in the opposite direction of a theory-predicted response to a pure monetary policy shock. Qualitatively the effects of the Fed information shocks are similar to the effects of other 'macro news shocks' in the US (using series of Scotti (2016)), although more pronounced. The effects of the Fed information shocks are contrasted with the effects of 'pure monetary shocks'. Perhaps surprisingly in the light of the established evidence for the Fed's global impact through financial channels, I find no support for the pure monetary shocks' ability to stir a real economic response in Europe through trade links that account for global value chains.

1.1 Related literature

This paper is in between the immense literature on international spillovers of the Fed policies and the literature on central bank shocks that are other than 'pure monetary policy'. The Fed has been pointed out as a source of global shocks (prominently in Rey (2013), Miranda-Agrippino and Rey (2020)), affecting particularly emerging market economies (Kalemli-Özcan (2019)). A debate centrally related to this paper is therefore the Federal Reserve's role as a global central bank (see Bernanke (2015)).

The real economic international spillovers of the Fed's monetary policy are covered empirically at least by Degasperi et al. (2023), Kim (2001), Dedola et al. (2017), Georgiadis (2016), Bräuning and Sheremirov (2019) and Iacoviello and Navarro (2019). These papers perform a country-level analysis of a wide range of advanced and emerging economies and examine a battery of economic indicators on exchange rate regime, financial conditions, capital flows and trade. With a more global view, they generally bear a message of globally contractionary real economic effects of US monetary policy tightening and heterogeneous patterns difficult to pin down by a single country feature. [1] Their results on the importance of trade links for cross-border monetary transmission are mixed, with more support (Bräuning and Sheremirov (2019)) or less support (Kim (2001)) for its significance (Iacoviello and Navarro (2019) attribute a large effect to trade in AEs but small in EMEs). This paper takes a different approach as it is focused on trade related input-output linkages and takes a closer perspective on the heterogeneous industries within a block of advanced economies belonging to the same monetary union, the euro area. It also follows a rather different methodology for addressing trade exposure or identifying the Fed shocks[2]. The effects of purged Fed monetary shocks on the EA real activity are covered at least in Degasperi et al. (2023), Jarociński (2022) and Ca'Zorzi et al. (2020) who find adverse effects of Fed monetary policy shocks when the response is on aggregate production.

Research taking methodologically a more similar approach to this paper, with an empirical sector-level

[1] The results of Degasperi et al. (2023) contrast the findings of heterogeneous patterns of the other studies as they find remarkably similar effects globally, except for a subset of EMEs.

[2] Among them, Degasperi et al. (2023) is closest to this paper's monetary policy shocks. Bräuning and Sheremirov (2019) also examine monetary shock transmission through trade networks, but without targeting input-output linkages as this paper does.

analysis and intersecting with the production network literature include Ozdagli and Weber (2017), di Giovanni and Hale (2021), Ghassibe (2021) and di Giovanni and Rogers (2022). The outcome of interest is stock prices in Ozdagli and Weber (2017) and di Giovanni and Hale (2021), sectoral consumption in Ghassibe (2021) and investment in di Giovanni and Rogers (2022). These papers pertain to monetary policy shocks only and differ in their approach to the identification method of the shock. Theoretical contributions to monetary policy shock propagation in a multi-sectoral New Keynesian setting include among others Pasten et al. (2020), Carvalho (2006), Nakamura and Steinsson (2010), La'O and Tahbaz-Salehi (2020) and Wei and Xie (2020).

The literature on central bank information effects is smaller and newer than that of monetary policy. Besides the literature studying the central bank information effects per se, numerous other works feature the channel by taking the approach of controlling for the information channel while examining the transmission of 'pure' monetary policy itself. The demand shocks that are under study in this paper – the Fed information shocks of Jarocinski and Karadi (2020) – are attributed to the central bank information channel, as it is the most prominent among the theories explaining the non-textbook-like public reaction to central bank announcements. Miranda-Agrippino and Ricco (2021) and Cieslak and Schrimpf (2019) follow methodologically similar identification strategies. The central bank information channel goes back at least to Romer and Romer (2000) and is subsequently addressed in the more recent influential papers of Campbell et al. (2012), Melosi (2017) and Nakamura and Steinsson (2018). A strand of this literature addresses the information channel in connection with forward guidance and involves Campbell et al. (2012), Andrade et al. (2019) and Andrade and Ferroni (2021). As this paper, Jarociński (2022) and Nunes et al. (2022) also relate macroeconomic news release surprises to central bank information shocks.

Close to the objective of this paper, Jarocinski and Karadi (2020) and Hansen and McMahon (2016) assess real macroeconomic implications of the Fed information shocks on output, but for the domestic economy. With the same series of shocks as studied here Jarocinski and Karadi (2020) observe opposite sign US GDP response to Fed information and monetary shocks in their BVAR. Hansen and McMahon (2016) assess real economic effects of different Fed shocks but relying on a textual analysis with a different identification approach embedded in their FAVAR; they observe generally expansionary effects of a positive Fed information shock on US real activity, albeit with much uncertainty.

The central bank information channel relies on the revelation of central bank's private information about the state of the economy. Alternative mechanisms have been proposed for how the central bank may surprise the public during the monetary policy announcement with shocks other than purely exogenous monetary policy. Bauer and Swanson (2023a) argue that the central bank responds to the same macro news as the markets do, but the information asymmetry is in the central bank's reaction function that is not perfectly predictable, generating an abrupt repricing of financial assets. Cieslak and Schrimpf (2019) emphasises the role of central bank news affecting financial risk premia. Sastry (2021) adds to the existing theories with the public's different confidence in public signals. Uribe (2022) introduces a different line of reasoning for expansionary interest rate increases through the Neo-Fisher effect that arises in New Keynesian models with expectations of permanent monetary policy shocks. This paper is not positioned to provide answers on where the information asymmetries between the central bank and the public lie. Noting that alternative theories are plausible, the non-monetary shocks under study are nonetheless labelled as 'Fed information shocks' as this term speaks to most of the relevant literature.

International effects of the Fed information shocks are present in papers studying the link between the central bank information shocks and the exchange rate: Gürkaynak et al. (2021), Stavrakeva and Tang (2019), Franz (2020) and Pinchetti and Szczepaniak (2023); and the spillovers of Fed information shocks through capital flows, risk and financial channels: Hoek et al. (2022), Bekaert et al. (2024), Pinchetti and Szczepaniak (2023), Georgiadis and Jarocinski (2023), Jarociński (2022) and Cesa-Bianchi and Sokol (2022). Besides this paper, few other works touch on Fed information shocks' cross-border real economic impact, with the exceptions of Jarociński (2022), Georgiadis and Jarocinski (2023) and Pinchetti and Szczepaniak (2023) whose focus lies elsewhere than on transmission through trade links. They find generally an expansionary effect of the Fed information shock on foreign real activity. This paper contributes to this body of evidence documenting a more nuanced effect depending on the industry's status as ultimate importer or exporter vis-à-vis the US, and shows that EA industries are hit by the shock also through the traditional expenditure-augmenting effect. The findings are consistent with the Fed information shock representing a positive demand shock with a global reach, reading by the global price responses it stirs.

2 Empirical strategy

I employ a panel local projections model first put forth by Auerbach and Gorodnichenko (2013), who build on the local projections methodology introduced in Jordà (2005). The local projection method has the advantage over vector autoregression of being readily applicable to a panel setting. This estimation methodology exploits both between- and within-industry variation; the time dimension of the panel allows us to observe the dynamic effects of the shock transmission, while the cross sectional variation in the time-fixed trade-related variables (backward and forward participation, upstreamness) provide information on how these industry-level features matter for the response to the central bank shock, which I capture by including interaction terms with the trade-related variables. With an externally identified series of exogenous policy shocks I do not need to restrict the coefficients of the impulse response functions (further from the original identification scheme that is conducted outside the current model). This section first introduces the key variables employed in the empirical model which is specified at the end of the section.

2.1 Central bank shocks

The theory of a central bank information channel is supported by a stock market reaction that runs counter to the standard textbook intuition of the demand dampening effect of monetary policy: occasionally monetary policy tightening leads to an *appreciation* of equity prices, despite the fact that corporate cash flows should be diminished by a monetary policy-dampened demand and those cash flows are discounted with interest rates that rise with policy rate tightening, which taken together should unambiguously depress equity prices. A plausible explanation behind the puzzling market reaction is that monetary policy announcements produce two types of shocks to the public; one that surprises the markets by the central bank's monetary policy action (a 'pure monetary policy shock'), and another that surprises the markets by the revelation of the central bank's outlook on the economy (a 'central bank information shock'). An appreciation of stock prices upon a monetary tightening can be rationalised as a reflection of an upswing in economic activity, predicting higher corporate cash flows that boost equity prices despite the countering monetary policy action, while the opposite holds true for monetary easing that depresses equity prices.

For the stock market reaction around FOMC announcements to be taken as a reliable beacon of the underlying state of the economy, two conditions need to be met. First, the Fed needs to be correct about the state of the economy and, second, stock markets must be able to interpret the announcement and translate it accurately into equity valuation. That is, the stock market analysts receiving simultaneously the *two countering signals* that accompany Fed information shocks, one towards a stock price rise (positive economic outlook) and another towards a stock price fall (monetary offsetting) need to be able to evaluate which effect dominates in the equity valuation.

Given the challenge of this task, what we read as economic news based on stock price reaction could be just a residual component of the HFI monetary policy shocks that has no clear significance for economic outcomes. Admittedly, financial variables, such as equity prices, may be instrumental for the identification of the shock type as they can be measured at a high frequency, as are the interest rate changes within the monetary announcement window. Moreover, equity prices have a clear theoretical link to corporate performance and thus also to the state of the macroeconomy. However, being financial variables stock prices are prone to sentiments that can produce overreactions and rapid reversals in the data, which can be mistaken for signals of economic fundamentals. Given these limitations, equity price changes may produce noisy signals about the public's interpretation of the central bank announcements.

The Fed information shocks' identification strategy of Jarocinski and Karadi (2020) is consistent with alternative explanations for the puzzling public reaction to central bank policies besides the central bank information channel, such as "Fed response to news channel" of Bauer and Swanson (2023a) or the Neo-Fisher effect of Uribe (2022). This paper takes an agnostic view of whether the central bank has superior inside information about the state of the economy over the markets, or whether the abrupt interest rate adjustment upon Fed move derives from another form of misalignment between the central bank and markets on how macro news be translated into interest rate changes. The bottom line is that the associated stock repricing during monetary announcements is indicative of the markets' perception of the underlying aggregate economy and the hypothesis is that it is informative also about real economic effects that follow from the distinct types of shocks.

The chosen Fed shocks under study are from Jarocinski and Karadi (2020) which in a short while have become part of the standard toolkit of empirical macroeconomists, making them an object of interest for this paper. In concrete terms, they make use of the interest surprises of Gürkaynak et al. (2005) whose database for the US is updated until June 2019 and is adjusted beyond the original paper to reflect also the Fed press conferences. The interest rate surprises are measured from the change in the three-month Fed funds future contracts, as the three-month horizon reflects the shift in the expected federal funds rate following the next policy meeting, considering that typical interval between policy meetings is six weeks. Thus, the surprises involve the effect of actual policy rate changes as well as the very near-term forward guidance. The surprises are measured in a time window starting 10 minutes before the announcement (typically occurring via a press release) and 20 minutes after.

The stock price surprises of Jarocinski and Karadi (2020) are measured as the change in the S&P 500 index of 500 large US companies, also 10 minutes before and 20 minutes after the Fed announcement, which is considered to be a time frame invariant to anticipatory movements in pricing, such as the "pre-FOMC announcement drift" (Lucca and Moench (2015)). Jarocinski and Karadi (2020) use the surprises in these stock prices to disentangle the two types of shocks, 'pure monetary policy shocks' and 'central bank information shocks', in a sign restricted VAR, where the sign of the interest rate response is restricted by the positive stock price comovement for the 'central bank information shocks' and negative comovement for the 'pure monetary policy shocks'.

2.2 Trade links

The outcome of interest is euro area industries' response to the Fed shocks, conditional on the industries' trade links with the US and overall trade positioning in global value chains (GVCs). The overall GVC position of the industry is measured as the industry's 'upstreamness', and the trade exposure to the US economy is measured through the industry's 'forward' and 'backward participation' (described below). It is worth emphasising that the backward and forward participation measures of the euro area industries are computed with respect to the United States specifically, such that they measure to what extent a given EA industry is ultimately a supplier or a customer of US firms. The measures of trade exposure to the US comprises direct trade between the EA and the US, as well as indirect trade of value added through countries other than the EA and the US. The analysis accounts for indirect trade, firstly, noting that about 70% of international trade today involves global value chains and thus indirect trade in value added.[3] Secondly, considering that the

[3] OECD, https://www.oecd.org/trade/topics/global-value-chains-and-trade/. To be counted as GVC-related trade, the traded goods generally need to cross more than one national border.

Fed shocks can have a global impact, indirect trade is included in the analysis, such that spilled over US demand and supply to 'third countries' that further propagate to the euro area, is accounted for.

The WIOD data used to construct the trade related variables are annual, and the measures constructed using the WIOD data (i.e. an industry's backward and forward participation and upstreamness) are held fixed over time at the average values over the years of data availability (2000-2014). This simplification is done noting that the results are robust using just the latest (year 2014) values of the trade measures or annually varying values. Therefore, it seems to be the case that the industry's relative trade exposure vis-à-vis the US (backward and forward participation) or GVC position (upstreamness) are rather structural features of the industries that do not fluctuate much over the time period considered in the empirical analysis (2000-2019) at the industry-level of aggregation.[4] This implies that global value chain configuration does not have an endogenous response to the central bank shocks and we can consider the trade-linkages across industries as exogenous. I create dummies based on the top-quartile of the industry distribution of a given trade related variable. This allows to study the impact of the shock under a *strong one-sided trade exposure* of the industry, with the purpose of utilising the industries' asymmetric input-output linkages to describe the nature of the shock (representing a demand shock of a positive or negative sign, or neither). Hence, I compare e.g. the top-25% most forward-participating industries vis-à-vis the US against the rest, since these industries are very exposed to the US in their exports (relative to the rest of EA industries) and are likely to experience the Fed shock distinctly given this feature.

2.2.1 Trade exposure to the US: backward and forward participation

The forward participation measure of the country-industry *ir* with respect to country *j* (through any intermediate country *m,k* and industry *l,t*) is computed as:

$$FW_{ij}^{r} = \frac{\sum_{s=1}^{S} F_{ij}^{rs}}{VA_i^r} + \frac{\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{s=1}^{S} a_{ik}^{rl} F_{kj}^{ls}}{VA_i^r} + \frac{\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{s=1}^{S} a_{ik}^{rl} a_{km}^{lt} F_{mj}^{ts}}{VA_i^r} + \dots \tag{1}$$

where $a_{ik}^{rl} = \frac{Z_{ik}^{rl}}{Y_k^l}$, i.e. value added ($Z_{ik}^{rl}$) from country-industry *ir* to *kl*, as a share of the *importing* industry's output, (Y_k^l), and $F_i^r \equiv$ final goods produced in country-industry *ir*.

The value added from EA ultimately exported to the US is normalised by the *exporting* (EA industry's) total value added, VA_i^r in order to normalise by the industry size in a way that reflects the proportional significance of the value added that ends up in the US, out of the entire value added created by the EA country-industry. Details of the construction of the measure as relegated into the Appendix A.1. The forward participation measure indicates how much an industry exports its value added to other industries, i.e. to what extent an industry is a supplier of goods to other industries. The measure indicates a given EA in-

[4]Some of these trade links that are considered structural until end-2019 may have changed after 2019; being temporarily disrupted during the Covid pandemic or are becoming permanently severed in geopolitically motivated reorganisation of trade relations.

dustry's exposure to country *j* through direct and indirect trade in value added trough its exports. The final destination is fixed to *j=US* and ultimate source is fixed as *i* = {Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal} for the forward participation measure.

Similarly, the backward participation measure of the country-industry *js* with respect to country *i* is defined as:

$$BW_{ij}^{s} = \frac{\sum_{s=1}^{S} F_{ji}^{sr}}{VA_{j}^{s}} + \frac{\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{s=1}^{S} a_{jk}^{sl} F_{ki}^{lr}}{VA_{j}^{s}} + \frac{\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{s=1}^{S} a_{jk}^{sl} a_{km}^{lt} F_{mi}^{tr}}{VA_{j}^{s}} + \dots \tag{2}$$

The backward participation measure indicates to what extent an industry imports value added from other industries. The final destination is fixed to *j* = {Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal} and ultimate source is fixed as *i=US* for the backward participation measure. The measure is normalised with the *importing* (EA) country-industry's total value added, VA_{j}^{s}, to reflect the proportional significance of ultimate US imports from the perspective of the EA industry.

2.2.2 GVC position of an industry: upstreamness

I compute the industries' upstreamness measure as:

$$u_{i}^{r} = 1 \times \frac{F_{i}^{r}}{Y_{i}^{r}} + 2 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs} F_{j}^{s}}{Y_{i}^{r}} + 3 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{t=1}^{T}\sum_{k=1}^{K} a_{ij}^{rs} a_{jk}^{st} F_{k}^{t}}{Y_{i}^{r}} + \dots \tag{3}$$

where again $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_{j}^{s}}$, i.e. value added ($Z_{ij}^{rs}$) from country-industry *ir* to *js* as a share of the *importing* industry's output (Y_{s}^{j}), and F_{i}^{r} ≡ final goods of country-industry *ir*. The upstreamness measure is normalised here by the *exporting* industry's output (Y_{i}^{r}) to adjust for the size of the EA industry. The index can be defined as a value-weighted count of the number of stages that the goods (value added or final) of an industry passes through, prior to reaching final absorption (Johnson (2018)). The smallest value the index can take is 1 for the final goods sold directly for consumption, inventories or capital accumulation; the larger the value, the further away the value added of the industry is from its final use. Details on the construction of the trade related variables are relegated to the Appendix A.2.

2.3 The main panel local projection model

The main panel local projections (LP) model is a series of H regressions:

$$\begin{aligned} x_{t+h,ir} = {} & \alpha_{h,r} + \beta_{h}^{\epsilon}\epsilon_{t} + \beta_{h}^{fw} fw_{ir} + \beta_{h}^{bw} bw_{ir} + \beta_{h}^{u} u_{ir} \dots \\ & + \phi_{h}^{fw}\{fw_{ir}\epsilon_{t}\} + \phi_{h}^{bw}\{bw_{ir}\epsilon_{t}\} + \phi_{h}^{u}\{u_{ir}\epsilon_{t}\} \dots \\ & + \psi_{h}\mathbf{z}_{t,ir} + \tau_{i} + \eta_{t+h,r} \qquad \text{for} \quad h = 0, 1, \dots, H-1 \end{aligned} \tag{4}$$

where $x_{t+h,ir}$ ≡ the industry outcome variable of interest (industrial production), $\alpha_{h,r}$ ≡ constant for the unique country-industry *r* at horizon *h*, ϵ ≡ central bank shock, *bw* ≡ backward participation, *fw* ≡ forward participation, *u* ≡ upstreamness, ***z*** ≡ a vector of control variables, including linear, quadratic and cubic trends, τ_{i} ≡ country fixed effects, and $\eta_{t+h,r} \equiv$ the residual.

As explained, I define dummy variables for the trade variables (backward- and forward participation and upstreamness) defined in Section 2, such that the dummies equal 1 when the variable takes a value above the 75th percentile of the distribution of the given trade variable and zero otherwise. In other words, I separate the top-25% backward-participating, forward-participating and upstream industries from the rest. The backward and forward participation are the key variables that characterise the role of exposure to the US economy in the empirical model. An interaction of the shock with backward (the term $\phi_h^{bw}\{bw_{ir}\epsilon_t\}$) and forward participation (the term $\phi_h^{fw}\{fw_{ir}\epsilon_t\}$) conveys information on whether the industry's exported output or imported inputs transmit the Fed information shock to the euro area. As I am also interested in the role played by the industry's position in a value chain, I will interact the monetary policy term with the upstreamness of the industry (the term $\phi_h^{u}\{u_{ir}\epsilon_t\}$). The upstreamness variable u (and its interaction with the Fed shock) is not included for the main results of Section 3.1.1 as its only introduced in the LP for the results of Section 3.1.4.

Panel LP models have by construction autocorrelated residuals, given that the residual is a moving average of the forecast errors from $t > 1$ to $t + h$. Moreover, with a cross-sectional dimension there is a chance that observations are spatially correlated. To account for potential serial and spatial correlation of the residuals, I use Driscoll-Kraay robust (Driscoll and Kraay (1998)) standard errors (with a bandwidth of 4). The time dimension of my analysis spans from 2000:M1 to 2017:M12 and the frequency is monthly.

As the industry outcome variable of interest I use the industrial production index (IP-index), which describes the real economic performance of the EA industries. The analysis is restricted mainly to manufacturing firms as the industrial production index covers these industries. I select the initial 12 Euro Area countries[5] in my sample. These countries have been part of the euro area since its inception, which simplifies the monetary policy and exchange rate regimes that affected these countries in the sample period. The number of industries from this set of countries for which I obtain IP-index data amounts to 218 country-industry units. The time dimension of the panel is 216 periods (2000:M1-2017:M12).

The focus of this paper is on the transmission of the given Fed shock through real economic linkages, which informs us about the type of demand shock the EA industries experience the shock as. Noting that the Fed shocks are known to transmit also through financial channels, sentiments and expenditure switching effects, I include as controls variables representing markets' risk perception, financial channels and the 'global financial cycle' (Miranda-Agrippino and Rey (2020)). To address reverse causality from euro area driven demand, I will also control for EA macroeconomic and monetary variables. Namely, I control for: Euro stoxx 50 volatility and VIX indices; EUR/USD FX rate and USD broad value index (against a currency basket of 27 largest US trade partners); oil price; 2-year US Treasury yields, Eonia rate; excess bond premia of Gilchrist and Zakrajsek (2012), corporate spreads against the German Bunds of Gilchrist and Mojon (2017); euro area monetary policy; euro area real activity: EA industrial confidence, EA real activity index of Scotti (2016) (from a dynamic factor model with EA GDP, industrial production, unemployment, retail sales and purchase managers' index). The main results of Section 3.1.1 includes these controls for the Fed info shock during the time of the shocks and the six months preceding it. Robustness checks show that the results are rather invariant for the inclusion or exclusion of the contemporaneous or lagged controls, thus the external identification strategy from high-frequency financial data is rather effective.[6]

[5]The countries are: Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Greece, Netherlands, Portugal.

[6]The shock's robustness to the controls does not, however, preclude the central bank systematically releasing more than one

3 Empirical results

3.1 Fed information shocks

The results of this paper reveal that the Fed information shocks identified from high-frequency financial data stir real economic effects at the international level. Crucially, the impact depends on the industry's trade exposure to the US economy. This may not be the conclusion one draws by looking at the aggregate picture (Figure 1) of the response of the EA industrial production to the Fed information shock, averaged across all EA industries. Indeed, we observe that the effect of the Fed information shock appears to be rather insignificant on the aggregate, which may lead us to infer that these shocks do not really matter for European economic activity. This aggregate picture across all EA industries masks important heterogeneity in how EA trade partners experience the shock, which becomes apparent in Figure 2 as it breaks down the response to the shock by the industry's trade exposure to the US economy.

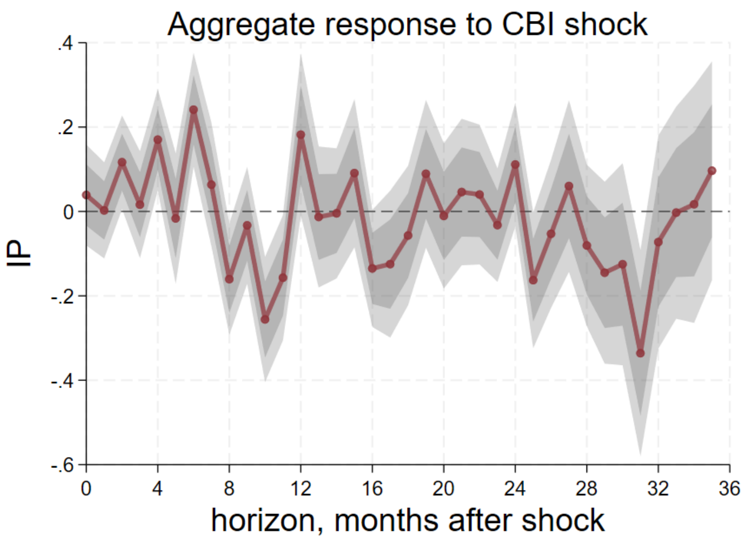


Figure 1: The response of EA IP-index to one standard deviation (positive) Fed information shock of 3 bps across all EA country-industry units. LP specification of Section 2.3 **without** variables *bw*, *fw*, *u* or related interaction terms. 68% and 90% confidence bands.

3.1.1 Main results

Figure 2 displays the response of EA industrial production broken down by trade exposure to the US economy, comparing the EA industries that are particularly exposed to the US via imports but not exports ('backward participating' industries, bottom panel) to the responses of EA industries that, conversely, are particularly exposed to the US via exports but not imports ('forward participating' industries, middle panel). To facilitate interpretation, throughout the paper the responses are to a Fed information shock that is scaled to one standard deviation positive shock. According to theory this is the kind of shock that represents an upturn in the US business cycle. The 'overall effect' of Figure 2 comprises the sum of coefficients of the main effect of the shock on the IP-index and the interaction term of the shock with the given US trade exposure.

shock simultaneously during the time window of policy announcement.

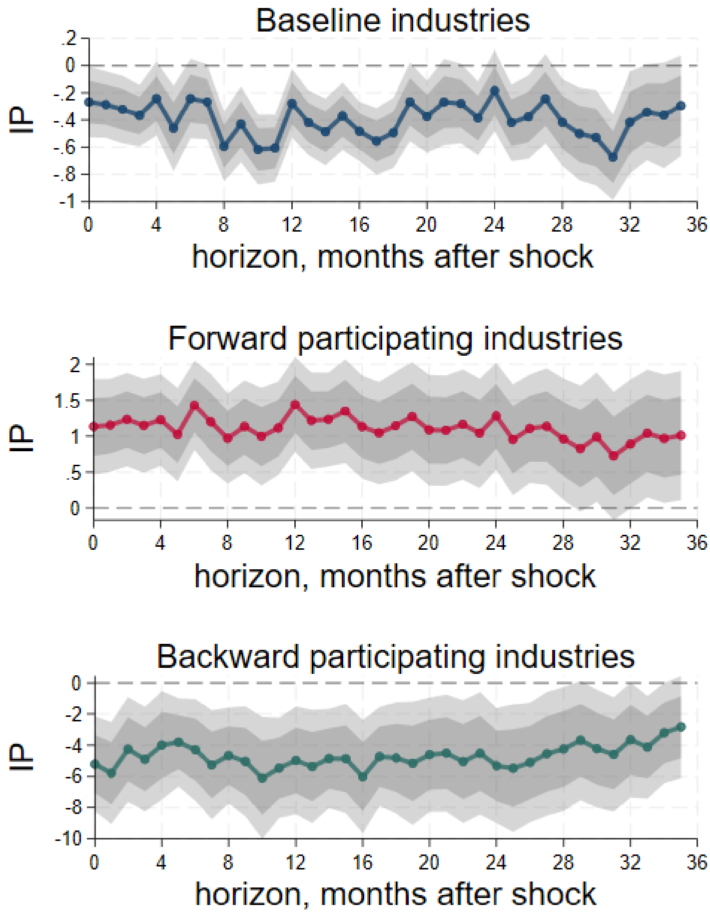


Figure 2: The overall response of EA IP-index to one standard deviation (positive) Fed information shock (of $\delta = 3$ bps). The (scaled) overall effects comprise main effect and interaction terms, i.e. $(\beta_h^{\epsilon} + \phi_h)\delta$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

Comparison of the bottom and middle panels of Figure 2 provides us with the key take-away: overall the Fed information shock has the opposite effect on forward and backward participating EA industries' activity. Hence, when the input-output linkages are asymmetric, the Fed information shock induces a drastically differing response for trade partners' real activity – in Europe a booming US economy is good news for some and bad news for others, and certainly not inconsequential despite the aggregate picture.

First, the bottom panel shows us that backward participating EA industries' production falls around 4-6 index points upon the Fed information shock, which represents about one third of the industry-level monthly standard deviation of the IP-index, i.e. a non-negligible variation in the EA industry-level activity. The adverse effect on this group of industries could be the outcome of having to compete (against the US or globally) with greater demand for inputs as the US economy booms (some evidence to that effect is reported in later in Figure 4). Second, the impact of the Fed information shock on the forward participating EA industries is the opposite as seen from the middle panel; these industries increase their production around 1-1.5 index points, possibly as a result of higher exports. The responses of both groups are statistically significant at the 90% confidence level. Third, the top panel ('baseline' industries) documents the effect of the shock on the EA industries that are not particularly exposed to the US economy through trade; these industries experience the Fed information shock mainly adversely, with a drop of about 0.2-0.6 index points in the industrial production index. Thus, the baseline group effect resembles mostly the effect that the Fed information shock has on the EA industries exposed to the US economy through imports, i.e. the backward-participating industries (bottom panel), suggesting that also the baseline industries likely have import exposure to the US, despite not being among the top-25% most backward participating industries. Moreover, the baseline group could be in general harmed by the price effects stirred by the shock (details below for Figure 4).

The EA industrial production index generally responds on impact and persists during the 3-year horizon, which is indicative of a response to a proxy of the US business cycle, which prevails already during the Fed announcement and evolves as a rather slow-moving process. Hence, the response is most likely to the underlying demand in the US that is present regardless of the announcement and not to the announcement itself, and the effect is predicted to continue to propagate internationally over the course of the following three years from the Fed announcement.

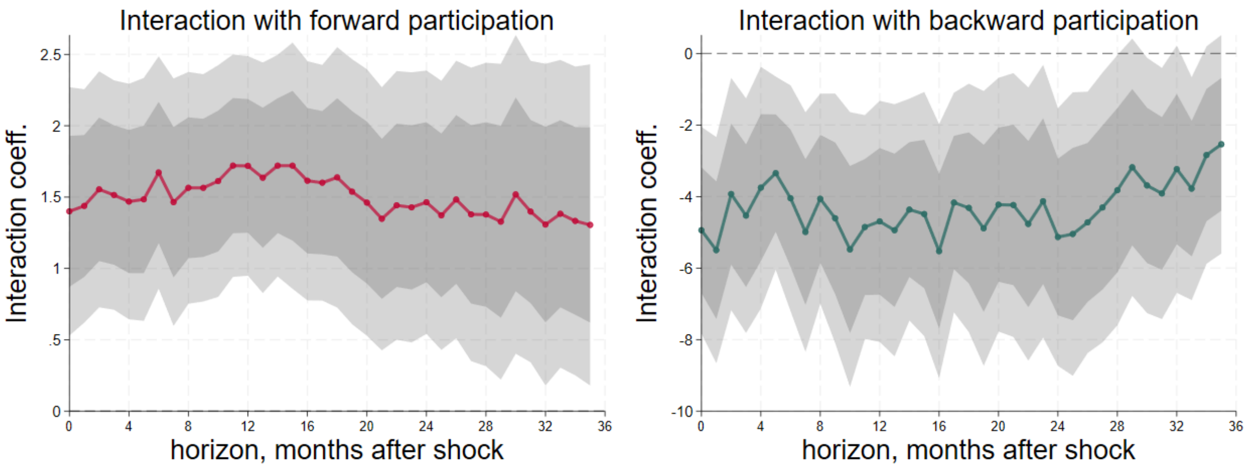


Figure 3: Interaction coefficients of the forward participation dummy (left) and backward participation dummy (right) with the Fed information shock, which is ϕ_h in the LP model of Section 2.3. The response of IP-index is scaled to one standard deviation positive Fed information shock. 68% and 90% confidence bands.

The differential effect of the Fed information shock becomes even more apparent looking at the coefficients of the interaction terms alone. Figure 3 displays the interaction coefficients terms only, between the trade-exposure variable and the Fed information shock. Upon the Fed information shock, forward-participating EA industries experience an offsetting 1.5 index point boost from the mildly adverse main effect of the shock by belonging to the group of most forward participating industries. To the contrary, backward participating industries experience an additional 3-5 index point drop from the main effect.

The main message of the results shown in Figures 2 and 3 is that there is substantial heterogeneity among EA industries that have the opposite input-output linkages with the US economy; backward participating industries receive a great deal of their input (ultimately) from the US while forward participating industries' output is exposed to the US through their exports. At the same time, these industries do not have an offsetting exposure to the US, since they are characterised by a rather one-sided exposure (being predominantly either exporters or importers via-à-vis the US, but not both). These figures demonstrate the advantage of studying the real effects of the Fed information shocks through international data; world input-output tables come in useful controlling for input-output linkages that produce an offsetting overall effect for a given foreign demand shock. Utilising the distinct, one-sided, exposure to the US economy that a foreign industry may exhibit clears much of the ambiguity in the real economic effects of the Fed information shocks that we observe from looking at aggregate effects, as in Figure 1, or what we could observe looking at domestic US industries who are unlikely to have such a one-sided exposure to the US economy (from the side of sales of output or purchases of input, alone). These results are informative since, if the Fed information shock had no clear economic significance, we would be unlikely to observe a response that is symptomatic to a higher demand in the US economy for foreign goods. At the same time, the fact that ultimate US importers suffer from the same shocks that lead US stocks to appreciate, points at a strong US economy which means either paying more for US imports or reducing the consumption of US goods to the extent they are substitutable. We turn to the price effects next.

3.1.2 Price responses and US net imports

The price signals induced by the Fed information shock lend support to the interpretation that the shock could also lead to higher costs in the EA which represent the 'bad news' of the shock. Here, each variable's response is estimated through a simple lag-augmented local projection:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h^{\epsilon}\epsilon_t + \psi_h \mathbf{z}_{t-j} + \eta_{t+h} \qquad \text{for} \quad h = 0, 1, ..., H-1 \tag{5}$$

where $y_{t+h} \equiv$ the dependent variable, i.e. either the US net imports or the given price index; $\alpha_h \equiv$ constant; $\epsilon \equiv$ the Fed information shock, $\boldsymbol{z} \equiv$ a vector of controls (6 lagged values of the dependent variable; linear, quadratic and cubic trends; monthly dummies for seasonal effects, and additionally for the EA prices: EA monetary policy, EA industrial confidence and EA real activity index of Scotti (2016) up to 6 months prior to shock); and $\eta_{t+h} \equiv$ the residual.

We see in Figure 4 that the Fed information shock manifests itself in international prices as measured by global commodity prices as well as the prices of EA imports from outside the EA. The commodity price index is a comprehensive price index including all commodities in the IMF database and are traded in global markets. The EA import prices are reported for the categories of goods that are likely the most relevant for the EA manufacturing industries: capital goods, manufacturing goods as well as intermediate goods. Notably, these are extra-EA import prices i.e. prices that European firms pay for their imports globally. [7]

On the side of euro area import prices, we observe that the Fed information shock raises import prices in capital goods, intermediate goods and manufacturing goods. The higher import prices that EA firms have to pay is a likely contributor to the adverse effects of the Fed information shocks reported in Figure 2 also for the baseline group that is not particularly linked to the US. The EA import prices rise the most for capital goods, which all else equal contributes to scaling down production, at least for industries that not experiencing a demand boost for their products via exports. It is worth noting that the (small and statistically insignificant) rise in the manufacturing good import price could in fact generate an impact in either direction; as most of the EA industries under study are manufacturing industries, they could both gain as well as suffer from the observed small rise in manufacturing goods depending on their production technology.

All in all, the price responses to the Fed information shock are indicative of higher US global demand that cannot be met with global supply. Figure 5 confirms that the Fed information shock leads to greater demand in the US for foreign goods. The global price response of Figure 4 signals that the Fed information shock has a global reach and the interaction documented in the results above is therefore not only between the US and the EA. Moreover, the price effects make the Fed information shock a relevant matter also for industries that are not tied to the US through a GVC. Observing the commodity price index response, we see that the effect of the shock gradually passes through to

[7] Details of the data are included in the Appendix Section C.

global prices over a wide range of commodities, which likely has an impact towards the more upstream of industries within global value chains that are generally more commodity-exposed. The 'commodity price channel' detected by Degasperi et al. (2023) for Fed monetary shocks appear to prevail also for the Fed information shocks.

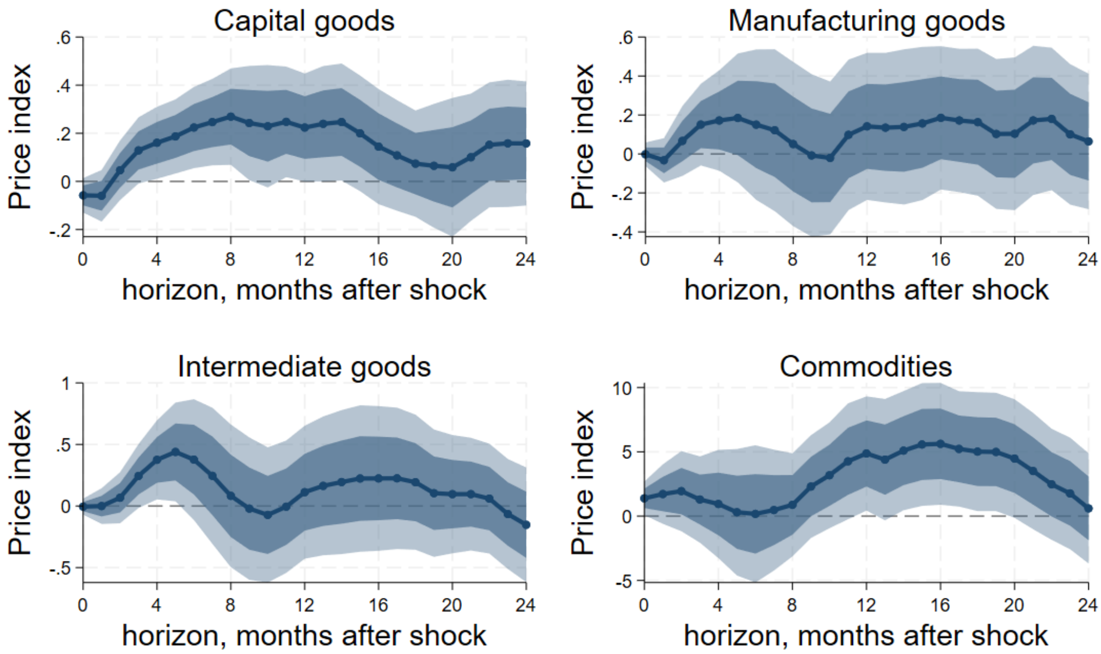


Figure 4: **EA import prices**: responses to one standard deviation positive Fed information shock of 3 bps. Vertical axis: price index in cumulative differences. 68% and 90% confidence bands.

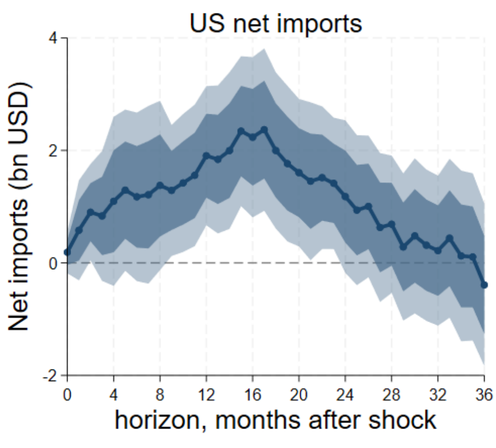


Figure 5: The response of real US net imports (in billions of USD) to one standard deviation positive Fed information shock of 3 bps. Vertical axis: net imports in cumulative differences. 68% and 90% confidence bands.

3.1.3 The exchange rate

The Fed information shock has an impact on EA industrial production presumably through a mix of channels, a key one being the exchange rate channel. The channel traditionally works through expenditure switching towards goods whose prices are denoted in a currency that depreciates. Let us first document the response of the bilateral EUR-USD exchange rate to the Fed information shock, by estimating a lag-augmented local projections model with the

EUR/USD-rate now as the dependent variable:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h^{\epsilon}\epsilon_t + \psi_h \mathbf{z}_{t-j} + \eta_{t+h} \qquad \text{for} \quad h = 0, 1, ..., H-1$$

where $y_{t+h} \equiv$ the FX rate; $\alpha_h \equiv$ constant; $\epsilon \equiv$ the Fed information shock, $\boldsymbol{z} \equiv$ a vector of controls (6 lagged values of the dependent variable; linear, quadratic and cubic trends; monthly dummies for seasonal effects; and $\eta_{t+h} \equiv$ the residual. Figure 6 shows that overall the US dollar tends to appreciate as a result of the Fed information shock, after a short-lived depreciation immediately after the Fed information event. The results of a brief depreciation followed by a longer term appreciation of USD against other advanced-economy currencies are also documented in Georgiadis and Jarocinski (2023) who rationalise the on-impact failure of the uncovered interest parity condition by a risk-on sentiment following positive Fed information shocks.

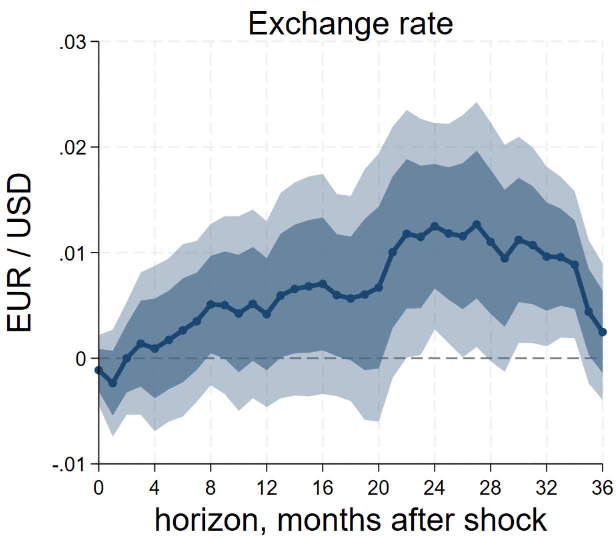


Figure 6: **EUR/USD rate**: response to one standard deviation positive Fed information shock of 3 bps. The FX rate is defined as euros per dollar, hence an increase in value means dollar appreciation. Vertical axis: FX rate in cumulative differences. 68% and 90% confidence bands.

The bilateral USD-EUR exchange rate as well as the broader value of USD is controlled for up until the time period of the shock for the main results displayed in Figures 1, 2 and 3. It is plausible, though, that the exchange rate's main effect on EA activity is ambiguous when a movement in the EUR/USD rate affects EA producers distinctly depending on their status as importers or exporters to the US economy, which calls for the inclusion of interaction terms between the exchange rate and the industry's exposure to the US economy. Hence, I simulate the effect of the Fed information shock in the same model specified in Section 2, except that I include as controls interaction terms for: (i) the EUR/USD-rate with the backward participation and (ii) the EUR/USD-rate with the forward participation in order to account for a differential response to exchange rates. Figure 8 suggests that expenditure switching effects do play a role for the distinct response of (ultimate) US exporters vs. importers to the Fed information shock; the magnitudes of the shock's effect are muted from those of the main results (Figures 2 and 3), yet bulk of the effect remains, and the results stay statistically significant.

This leaves a substantial proportion of the positive Fed information shock's influence on foreign trade partners attributable to the 'pure' demand effect of changed incomes, cash flows and expenditures in the US that reflect the US business cycle and resulting demand for foreign goods. Notably, it seems not to be the case that the US stock market response to the Fed announcement merely represents financial effects that translate into a reaction of the exchange rate which would drive real effects through expenditure switching, without an underlying booming US economy. Rather, both income and expenditure switching effects appear to be present.

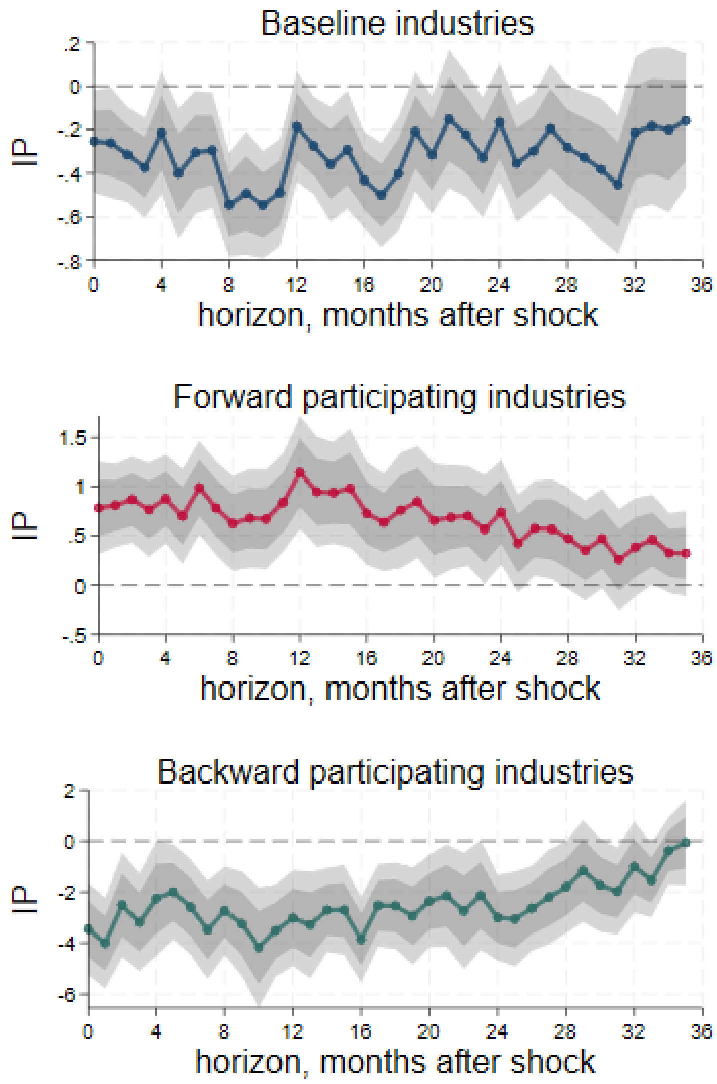


Figure 7: The overall response of EA IP-index to one standard deviation (positive) Fed information shock (of $\delta = 3$ bps) when interaction of FX rate with US trade exposure is included in the LP as control. The (scaled) overall effects comprise main effect and interaction terms, i.e. $(\beta^{\epsilon}_{h} + \phi_h)\delta$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

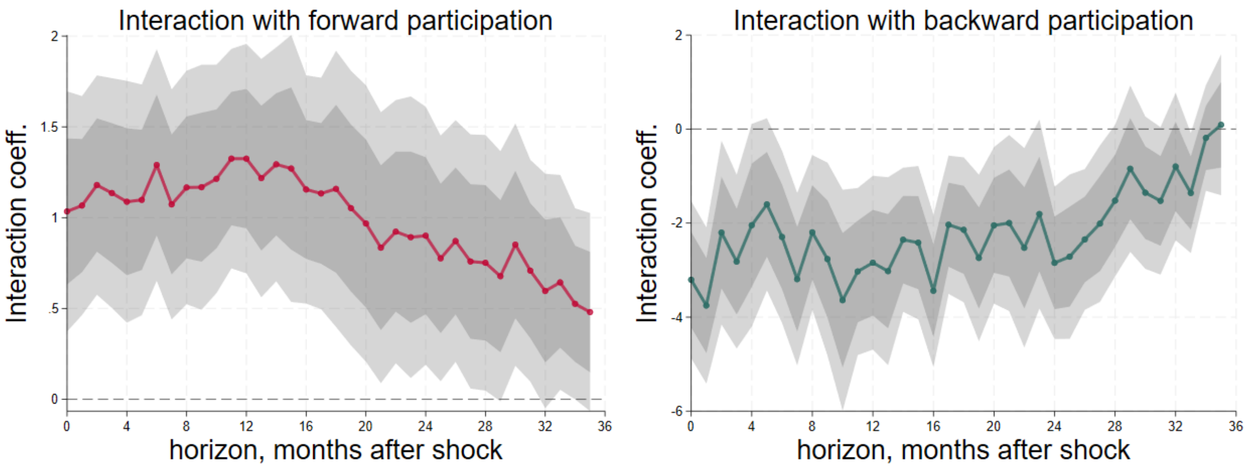


Figure 8: Interaction coefficients of the forward participation dummy (left) and backward participation dummy (right) with the Fed information shock, when interaction of FX rate with US trade exposure is included in the LP as control. The interaction response is $\phi_h \delta$ in the LP model of Section 2.3. The response on IP-index is scaled to a one standard deviation Fed information shock. 68% and 90% confidence bands.

3.1.4 GVC position: industry upstreamness

Lastly, I examine the impact of the Fed information shock based on the industry's global value chain position to form a view of whether the industries further away from final demand are affected by the Fed shock.[8]. Typically the more upstream an industry is, the more forward participating it is. This effect is largely present in Figure 9 where the industry's trade exposure to the US is unrestricted. The initial effect of the shock is positive but eventually subsides (unlike for the group of most forward participating industries), which could have to do with price effects, as e.g. commodity prices gradually rise. Noting that the EA industries here are manufacturing firms, typically placed in the mid-stream when considering the full scale of a value chain, these EA industries are not in the business of commodity extraction and sales, but instead these industries would be, if anything, buyers of these goods. Hence the observed rise in commodity prices of Figure 4 could account for the eventual adverse effect, yet it remains unclear what generates the initial boost.

Figure 10 documents the effect of the Fed information shock on upstream industries, but this time including the usual US trade exposure terms in the LP model, such that the upstreamness does not proxy forward participation. Figure 10 demonstrates how an upstream EA industry experiences the Fed information shock when it is not particularly trade exposed to the US economy and hence mainly receives the shock through the price effects. The interaction term reveals a pattern on how initially the industry benefits from its upstreamness which after a while turns into a harmful feature.

[8] I do so by adding the overall industry upstreamness into the main LP model of Section 2.3

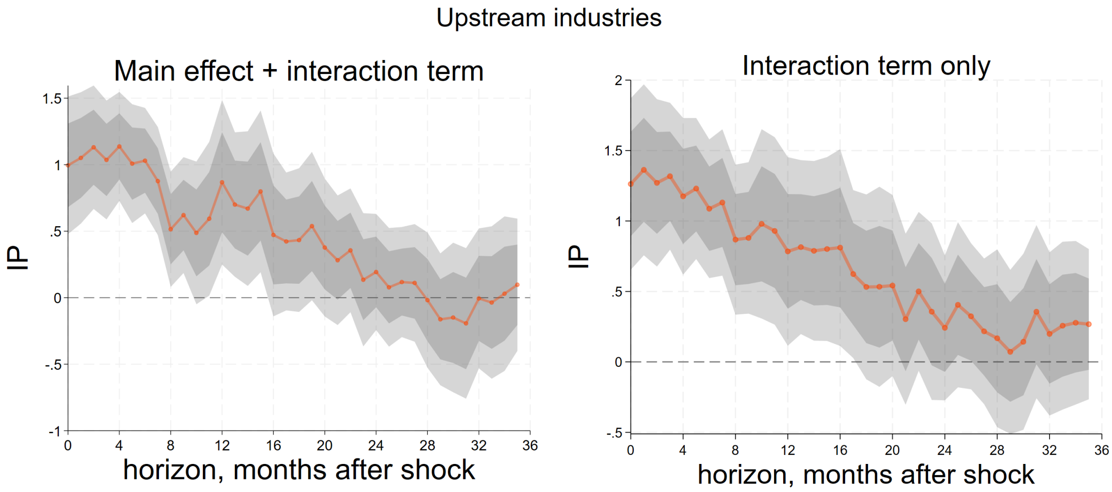


Figure 9: Impact of a positive one standard deviation Fed information shock on EA IP-index for the top-25% upstream industries, when US trade exposure is not accounted for. Left: Overall effects comprise main effect and interaction terms, i.e. $(\beta_h^{\epsilon} + \phi_h)\delta$ in the LP model of Section 2.3. Right: the interaction term only, scaled by the size of the shock, i.e. $\phi_h \delta$ only. 68% and 90% confidence bands.

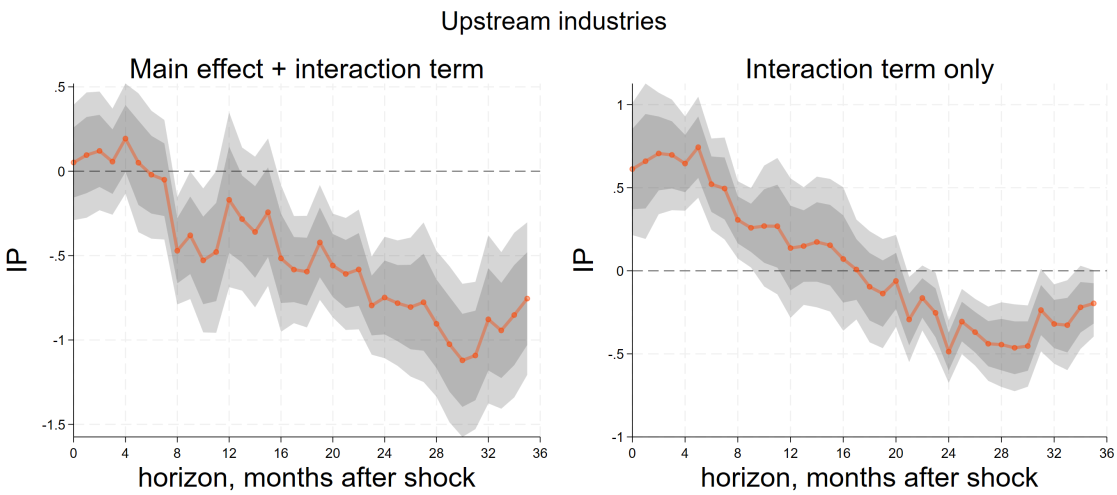
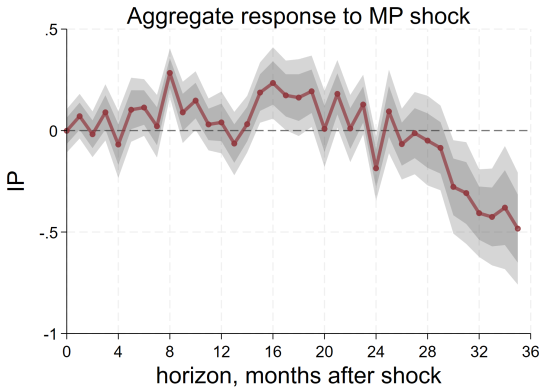


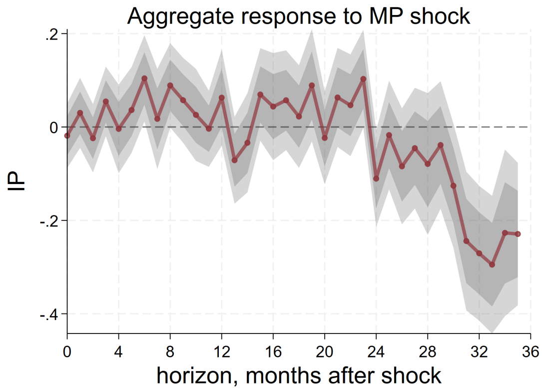
Figure 10: Impact of a positive one standard deviation Fed information shock on EA IP-index for the top-25% upstream industries, when US trade exposure is accounted for. Left: Overall effects comprise main effect and interaction terms, i.e. $(\beta_h^{\epsilon} + \phi_h)\delta$ in the LP model of Section 2.3. Right: the interaction term only, scaled by the size of the shock, i.e. $\phi_h \delta$ only. 68% and 90% confidence bands.

3.2 The pure Fed monetary shocks

This section turns to the impact of monetary policy shocks on EA real activity through trade links. The 'pure' monetary policy shocks are taken to represent exogenous variation in the policy rate that is not linked to the state of the economy. Figures 12 and 13 demonstrate the effects of 'pure' monetary policy shocks on EA production for the shock series of both Jarocinski and Karadi (2020) (Panel A, left) and Bauer and Swanson (2023b) (Panel B, right). The results are generated applying the same LP model of expression (4), but replacing the Fed information shock with the 'pure' Fed monetary shocks. Another key result of this paper is the missing real activity effects on EA industries from pure monetary policy shocks, which are presumed to represent demand shocks of the opposite sign of Fed information effects. In this respect the pure Fed monetary shocks are distinct from the Fed information shocks; the adverse effect on EA production, if any, seems to come with a significant delay and, notably, does not interact with trade exposure with the US economy.



Panel A. Jarocinski-Karadi exogenous monetary policy shocks.



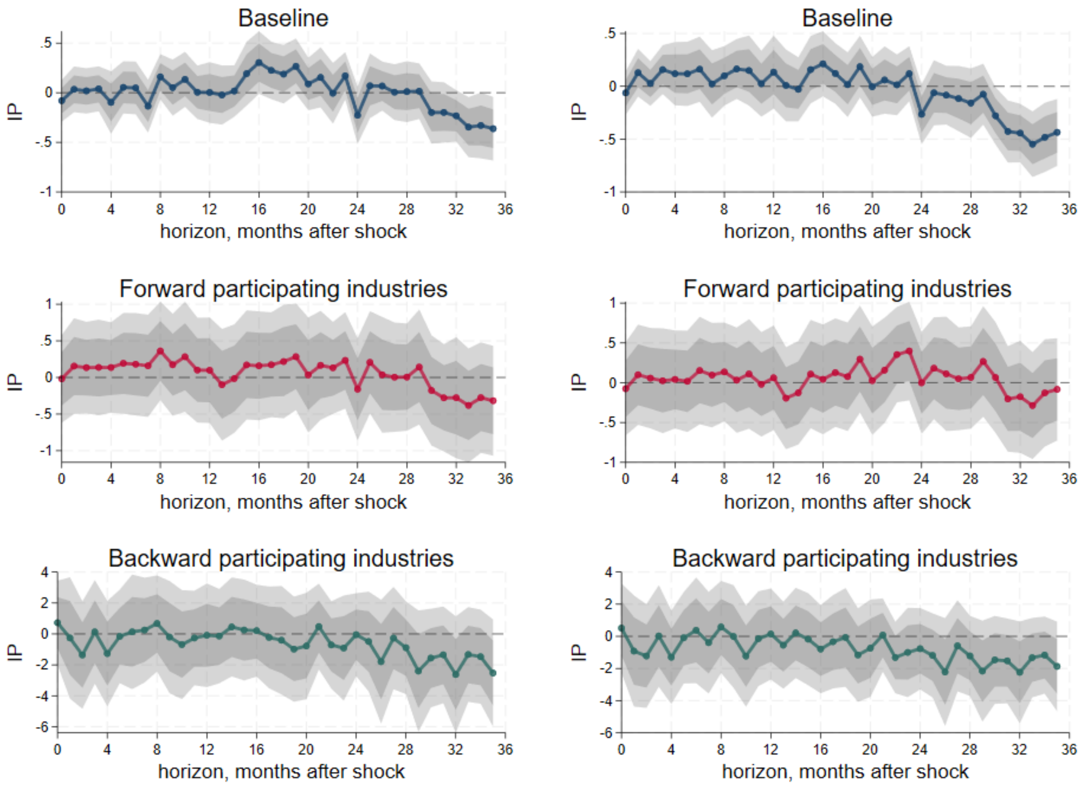
Panel B. Bauer-Swanson exogenous monetary policy shocks.

Figure 11: The response of EA IP-index to one standard deviation (positive) Fed monetary shock of 5 bps across all EA country-industry units. LP specification of Section 2.3 **without** variables *bw*, *fw*, *u* or related interaction terms. 68% and 90% confidence bands.

There are several plausible explanations for the observed lack of real effects, which this paper does not investigate further. Economically, it is possible that the pure monetary policy shock that is considered originating at the Fed and having an impact to the extent monetary policy is non-neutral (e.g. through nominal rigidities and financial conditions), produces a more muted global demand effect on international trade, compared to a proxy for the underlying US economic demand which the Fed information shock could be considered as. The global financial effects of the Fed monetary policy (which are outside the scope of this paper) are well documented by now. The results presented here do not preclude these effects but suggest a limited pass through to the real activity in the context of advanced economies, controlling for risk and financial channels. With a more global view, Degasperi et al. (2023) find that the cross-border transmission of Fed monetary policy to real variables largely operates via financial variables. It is noteworthy that the financial channel of US monetary policy is likely to be more powerful e.g. for emerging economies with a financial dependency of the US economy that is different for the EA. A robustness test lifting the controls representing risk and financial channels (Appendix) does report some adverse effects of the pure Fed monetary shock on the aggregate EA production, yet no robustness checks find interaction between EA US trade exposure and Fed monetary shocks, which is rather robustly present for the Fed information shocks.

Possibly contributing to the lack of real international effects from the pure monetary shocks is the issue of statistical power. Discussed e.g. in Nakamura and Steinsson (2018), high-frequency identification deals with much of the endogeneity concerns in identifying monetary shocks but comes with reduced statistical power. As the purged monetary shocks' size is diminished, the signal-to-noise ratio between the shock and the macroeconomic variable is often too small, which is why the effects of HFI monetary shocks are often studied in connection with other high-frequency financial data instead of lower frequency macro variables. Here, the part of monetary policy surprises that is purged and considered as exogenous is reduced to shocks with a standard deviation of about 5 basis points which falls substantially below the typical size of the AE central bank's policy rate change of 25-50 basis points, i.e. a size deemed macroeconomically effective by the typical AE central bank. In contrast, the Fed information shocks which are also scaled to a one standard deviation change (equal to about 3 bps) appear to capture the demand effects even when measured by small variations in financial prices. This could be rationalised by the function of the (positive) Fed information shocks as a proxy for very good macroeconomic news, while the pure monetary shocks, being exogenous and not proxying for anything, should be impactful only on their own and require sufficient magnitude to be macroeconomically potent.

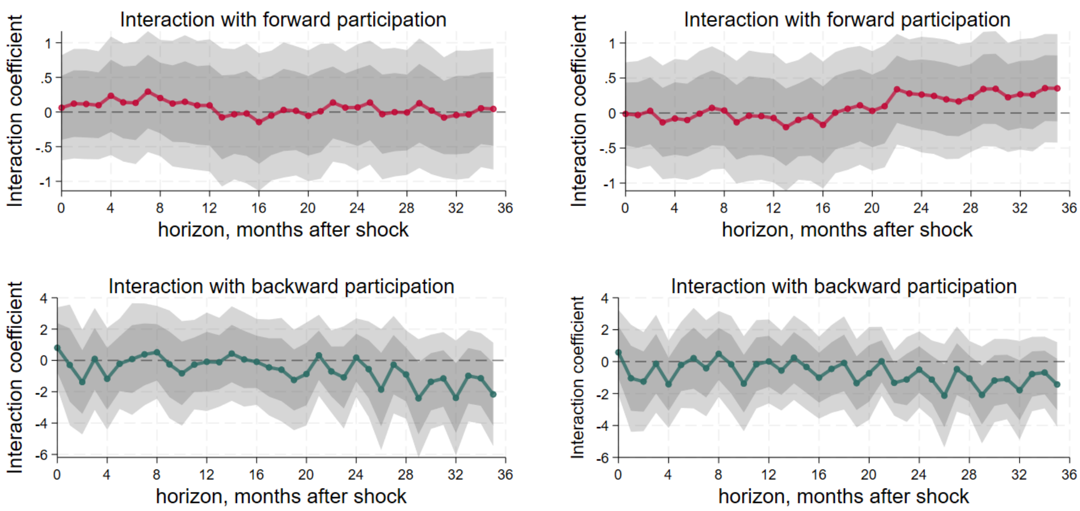
Additionally, much of the Fed's monetary policy communication happens outside the FOMC announcements or through forward guidance in advance of the actual policy rate change, which poses another challenge for capturing sizable surprises from the policy rate announcements alone. The financial markets are less surprised by the announcement itself if they are able to predict it from forward guidance, or receive it from Fed officials' public speeches etc. Hence, a large part of the pure monetary policy shocks could be not captured when accounting for only a part of the relevant events. Georgiadis and Jarocinski (2023) compare different Fed policy measures and find that the most consequential policy rate changes to the rest of the world are announced through forward guidance rather than as immediate policy rate changes. The econometric issue of a more systematically conducted monetary policy and broader central bank communication fora, which is raised also in Ramey (2016), makes the challenge of combining HFI monetary policy shocks with lower frequency macroeconomic data more dire in samples that cover the recent decades. Swanson and Jayawickrema (2023) make an attempt to mitigate the lack of variation by augmenting the set of monetary events beyond FOMC meetings. The 'statistical relevance' related issue of pure monetary policy shocks as statistical instruments is put forth also in Bauer and Swanson (2023a).



Panel A. Jarocinski-Karadi exogenous monetary policy shocks.

Panel B. Bauer-Swanson exogenous monetary policy shocks.

Figure 12: The overall response of EA IP-index to one standard deviation (positive) Fed monetary shock (of $\delta = 5$ bps). The (scaled) overall effects comprise main effect and interaction terms, i.e. $(\beta^{\epsilon}_h + \phi_h)\delta$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.



Panel A. Jarocinski-Karadi exogenous monetary policy shocks.

Panel B. Bauer-Swanson exogenous monetary policy shocks.

Figure 13: Interaction coefficients of the forward participation dummy (left) and backward participation dummy (right) with the Fed monetary shock, which is ϕ_h in the LP model of Section 2.3. The response of IP-index is scaled to one standard deviation positive Fed monetary shock. 68% and 90% confidence bands.

3.3 Other US macro news

This section presents the results of how US macroeconomic news impact EA industries, replacing the Fed information shocks with US macro news surprise series of Scotti (2016). The series measures surprises in the realisation of macro news relative to forecasters' consensus expectations for the macro data. A positive reading of the series means that the economic data was better than forecasters had expected. Hence, a negative value does not mean that the US economy was necessarily in a downturn, the realised value just did not reach prior expectations. The series serves as an informative point of comparison to the Fed information shocks since it represents *particularly* good and bad economic outcomes, which could be the type of events that would affect stock prices, in a similar vein to the particularly good or bad economic Fed news on the economic outlook despite an offsetting monetary policy action, which are the events the Fed information shocks of Jarocinski and Karadi (2020) are meant to represent. As for the analysis of the monetary policy shocks, in this section I apply the same local projections model of expression (4) in Section 2 and include the same set of controls.

Results in Figure 14 show the impact of macroeconomic news surprises on the EA industrial production. Qualitatively the results are in line with the effects of the Fed information shocks, with the main differences being in reduced statistical significance and magnitude of impact, particularly for the backward participating EA industries. On the whole, the US macroeconomic news surprises resemble the Fed information shocks in their impact on EA production. This corroborates the notion that the Fed information shocks reflect US macroeconomic news, and that the link between stock valuation and the macroeconomy is not just theoretical but the stock price reaction could be read as a useful proxy for the state of the economy.

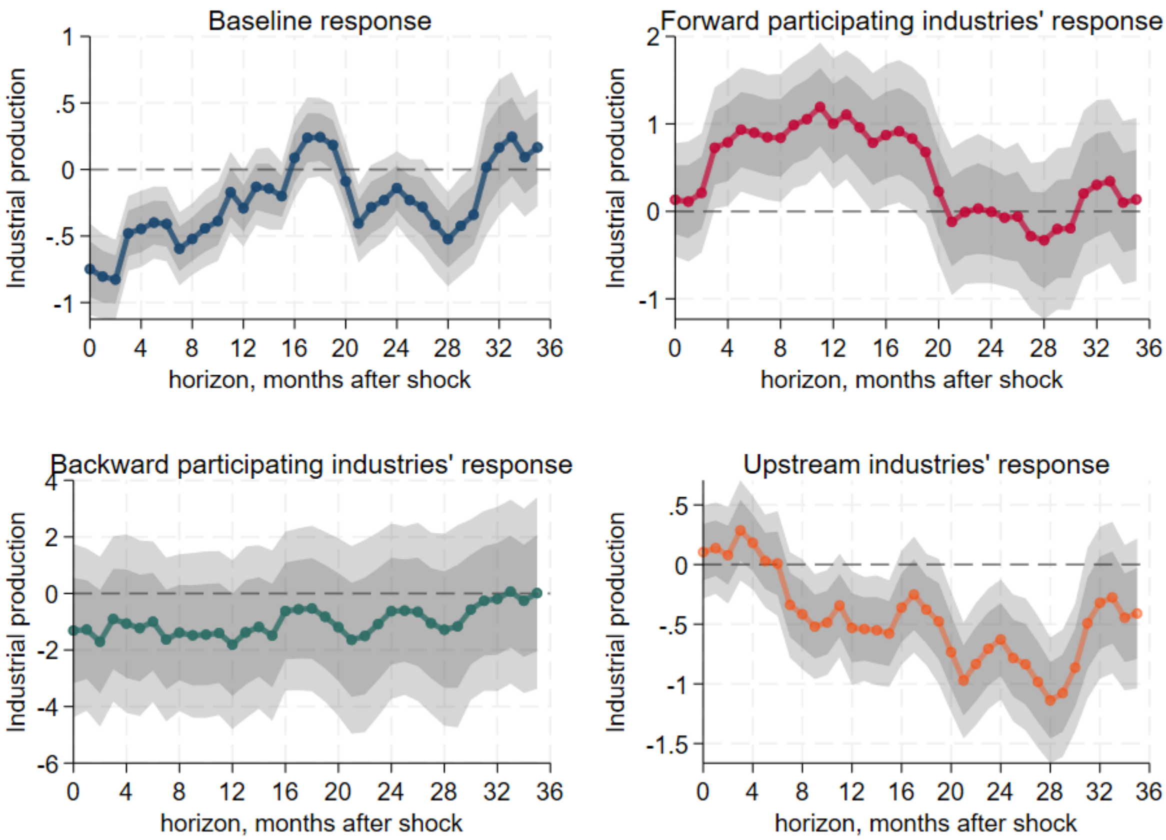


Figure 14: The overall impulse response function of EA IP-index to a one standard deviation macro news surprise. The (scaled) overall effects comprise main effect and interaction terms, i.e. $(\beta_h^{\epsilon} + \phi_h)\delta$ in the LP model of Section 2. 68% and 90% confidence bands.

4 Discussion

The empirical evidence brought forward in the previous section come with certain caveats. As I do not control for EA industries' trade with other countries than the US, those industries that are particularly backward- or forward participating with respect to the US, may be so also with respect to other economies. Hence, the forward- and backward participation measures vis-à-vis the US can proxy for trade links of the EA industries also with economies other than the US. When the Fed takes policy action (including communication) responding to the global developments that affect the US domestic economy, it can generate a Fed information shock. Hence, I might occasionally be capturing EA response to economic developments in some third country to which Fed responds, and I would capture it distinctly depending on the industry's trade exposure to the US insofar as the EA industries that are ultimate exporters to the US also also ultimate exporters to the third country. The theoretical possibility of this type of omitted variable bias cannot be excluded, although empirically it could prove difficult to capture this effect with statistical significance. This would require the Fed to frequently and consistently respond to the third country business cycle, as well as EA industries' US trade exposure to have a clear correlation with their trade exposure to the third country, as otherwise US would prove an irrelevant instrument for it. Econometrically there is no obvious bias, since the third country business cycle could push the Fed's response towards either monetary tightening or loosening, such that these kind of occurrences would likely represent noise in the estimates documented in this paper.

Another caveat worth considering is the role of supply-side US shocks. Throughout the paper the Fed information shocks are referred to as demand shocks, which is from the perspective of the EA industry. Of course, it is possible for the Fed to take policy action and make communications also when the US economy faces supply shocks. As discussed in Jarocinski and Karadi (2020), there is a possibility of misclassification of Fed information shocks as pure monetary policy shocks when the shock is a supply-side shock. Take for instance a disinflationary technological advancement which could lead the Fed to enact monetary easing to uphold target inflation. For stock valuation, the joint effect of technological improvement and monetary policy would unambiguously appreciate stock prices, leading to a positive co-movement of policy rates and stock prices, which is falsely classified as a pure monetary shock. From the perspective of the EA industry, however, the positive supply shock could be experienced as a positive demand shock from the US.[9] What is of interest for this paper's empirical analysis, are the potentially missing Fed information shocks that represent supply shock-driven demand in the US for EA goods.

As for the pure Fed monetary shock analysis, the supply-side Fed information shocks misclassified as pure monetary policy shocks could create an attenuation bias in the results, *if* they represent a positive demand shock since a pure monetary shock would have the opposite sign and the sample of pure monetary policy shocks is contaminated with misclassified information shocks counteracting their estimated impact on the EA activity.[10] Quantitatively the issue of misclassified supply-driven Fed information shocks is likely to be less pressing, since Jarocinski and Karadi (2020) find supply shocks (which they define as those information shocks driving output and inflation in opposite directions) not to account for much of the variation in their dependent variables.

Lastly, this paper treats the Fed information shocks as proxies for the underlying US demand for foreign goods and is agnostic about the source of information asymmetries between the central bank and the general public. Bauer and Swanson (2023a) find that economic news released in the days leading up to an FOMC announcement is an important omitted variable in the regressions of professional forecast revisions on monetary policy surprises (originally used in Campbell et al. (2012)), and controlling for the very newest economic data releases reproduces monetary policy coefficients in line with standard macroeconomic models. The findings of this paper do not allow us to take a stance on whether the Fed has private information about the state of the economy superior to the public, which is the assumption originally behind the central bank information channel, or whether the Fed and the markets learn and process equally the same newly arrived macroeconomic information. The message of these results is rather that the Fed information shocks identified from stock market reactions can be taken as a proxy for the underlying state of the US economy that bears distinct economic significance for trade partners' activity. If this feature exists, it would hold under either type of information asymmetry between the Fed and the public.

[9] A positive demand shock *if* US economic growth increases demand for foreign goods e.g. as the sectors that got more productive grow in size or the wealth effect of the productivity gain spills over more widely in the US economy.

[10] Given the Fed's dual mandate of maximum employment and price stability, a supply-side information shock would not be misclassified as a pure monetary policy shock in the event that the technology shock used as an example would raise employment exceedingly such that the Fed chooses to *raise* its policy rate.

Indeed, it is conceivable that foreign trade partners' response documented in the results is less so to the Fed announcement itself about how the Fed views the US economy but, rather, that the Fed information shock is a good proxy for the demand that develops regardless of the announcement. Otherwise, for there to be a systematic, statistically significant response from the EA trade partners, it would require EA business managers to maintain a constant surveillance of the FOMC announcements as well as to have an understanding of how their value added may ultimately end up in the US through all the (theoretically infinite) global value chain paths. For the purpose of using the Fed information shocks as reliable proxies of US demand for foreign goods, it suffices that stock market investors conduct constant Fed announcement surveillance and, crucially, have the ability to translate it into *domestic* US equity valuation that strikes the right balance between the impacts of macroeconomic developments and of monetary policy on the stock price.

5 Conclusions and next steps

This paper estimated the effect of Fed information shocks on euro area industrial production through a panel local projection model. The identification strategy of these shocks calls into question how the shocks materialise from a real economic point of view. These shocks are, by now, well-familiar to the literature as it has become the standard to control for the channel which they are taken to represent, when an exogenous representation of monetary policy is needed for empirical macroeconomic analysis. Yet, relatively little space in the literature is dedicated to what these residual "catch-all" shocks are, and what are the real economic outcomes that they stir. The results of this paper revealed that the Fed information shocks identified from high-frequency financial data extend to real economic effects across the Atlantic, yet the impact depends crucially on the trade-partner's exposure to the US economy.

The empirical model of this paper leans on the production network literature as it utilises cross-industry heterogeneity in trade exposure to the US, which serves to account for input-output linkages that generate ambiguous effects of demand shocks. The empirical approach unmasked sector-specific global value chain related patterns in the transmission of Fed information shocks to the euro area which become undetectable from aggregated data and informed us about which type of demand shock the EA industries experience the shock as.

The effects of the Fed information shocks were contrasted with those of monetary policy shocks that are classified as 'pure', and interestingly the pure monetary policy shocks appear to be inconsequential for the EA industries' production, such that any effects would arise through the exchange rate or financial linkages as opposed to real linkages. The effects of the Fed information shocks were subsequently contrasted with the effects of macro news surprises, with qualitatively similar outcomes arising from the two shocks. These findings further corroborate the idea that the central bank information shocks bear distinct economic significance also when identification is based on financial data and strong assumption on markets' ability to process the Fed news.

In short, the paper brings forth an economically meaningful finding: the impact of a positive Fed information shock on EA trade partners appear as a potent global demand effect. This supports the identification assumption that stock markets have the ability to process central bank announcements efficiently, such that researchers may treat the central bank information shocks as something with (real) economic meaning. The next step in order to finalise the paper is to build an open economy macro model that brings together the pieces of empirical evidence presented in the current manuscript.

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APPENDICES

A Trade related variables' construction

A simplified structure of a world input-output table is shown in Figure 15.

			Input use & value added							**Final use**			**Total use**
			Country 1			$\cdots$	Country J			Country 1	$\cdots$	Country J	
			Industry 1	$\cdots$	Industry S	$\cdots$	Industry 1	$\cdots$	Industry S				
Output supplied	Country 1	Industry 1	Z_{11}^{11}	$\cdots$	Z_{11}^{1S}	$\cdots$	Z_{1J}^{11}	$\cdots$	Z_{1J}^{1S}	F_{11}^{1}	$\cdots$	F_{1J}^{1}	Y_1^1
		$\cdots$	$\cdots$	Z_{11}^{rs}	$\cdots$	$\cdots$	$\cdots$	Z_{1J}^{rs}	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
		Industry S	Z_{11}^{S1}	$\cdots$	Z_{11}^{SS}	$\cdots$	Z_{1J}^{S1}	$\cdots$	Z_{1J}^{SS}	F_{11}^{S}	$\cdots$	F_{1J}^{S}	Y_1^S
	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	Z_{ij}^{rs}	$\cdots$	$\cdots$	$\cdots$	$\cdots$	F_{ij}^{r}	$\cdots$	Y_i^r
	Country J	Industry 1	Z_{J1}^{11}	$\cdots$	Z_{J1}^{1S}	$\cdots$	Z_{JJ}^{11}	$\cdots$	Z_{JJ}^{1S}	F_{J1}^{1}	$\cdots$	F_{JJ}^{1}	Y_J^1
		$\cdots$	$\cdots$	Z_{J1}^{rs}	$\cdots$	$\cdots$	$\cdots$	Z_{JJ}^{rs}	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
		Industry S	Z_{J1}^{S1}	$\cdots$	Z_{J1}^{SS}	$\cdots$	Z_{JJ}^{S1}	$\cdots$	Z_{JJ}^{SS}	F_{J1}^{S}	$\cdots$	F_{JJ}^{S}	Y_J^S
Value added			VA_1^1	$\cdots$	VA_1^S	VA_j^s	VA_J^1	$\cdots$	VA_J^S				
Gross output			Y_1^1	$\cdots$	Y_1^S	Y_j^s	Y_J^1	$\cdots$	Y_J^S	$\cdots$			

Figure 15: The structure of a world input-output table.

Antras and Chor (2022)

The world input-output data is aggregated from the national statistical agencies' input-output tables and is being produced with substantial lags; the latest version of WIOD covers data from 2014 on 43 countries (J=43) (with the rest of the world aggregated into one region) and 56 industries (S=56) classified under the UN's ISIC Rev. 4.

A.1 Backward and forward participation

The forward participation measure of the country-industry *ir* with respect to country *j* (through any country *m,k* and industry *l,t*) are computed as:

$$FW_{ij}^r = \frac{\sum_{s=1}^S F_{ij}^{rs}}{VA_i^r} + \frac{\sum_{k=1}^K \sum_{l=1}^L \sum_{s=1}^S a_{ik}^{rl} F_{kj}^{ls}}{VA_i^r} + \frac{\sum_{m=1}^M \sum_{k=1}^K \sum_{l=1}^L \sum_{t=1}^T \sum_{s=1}^S a_{ik}^{rl} a_{km}^{lt} F_{mj}^{ts}}{VA_i^r} + \dots \tag{6}$$

The value added from EA ultimately exported to the US is weighed by the EA industry's total value added, VA_i^r in order to normalise by the industry size in a way that reflects the proportional significance of the value added that ends up in the US, out of the entire value added generated by the country-industry.

The below states that gross output produced, Y (left-hand side), can be split into the uses (right-hand side) of final absorption,*F*, and value added use, *AY*, – all of which will ultimately be used for final absorption, in matrix notation:

$$Y = F + AY = F + AF + A^2F\dots \tag{7}$$

$$\Rightarrow Y = [\mathbf{I} - \mathbf{A}]^{-1}F \tag{8}$$

where the second lines results from an infinite geometric sum sequence, as $[\mathbf{I} - \mathbf{A}]^{-1} = \sum_{k=0}^{\infty} A^k$ (see also Antras and Chor (2022), Johnson (2018)), Carvalho and Tahbaz-Salehi (2019). The above expression can be normalised to express value added required to create the amount of final absorption F:

$$VA = \mathbf{VA}^{-1}[\mathbf{I}-\mathbf{A}]^{-1}F \tag{9}$$

where ***VA*** is a diagonal matrix with the value added-to-output ratios of all importing country-industries *js* along the diagonal, vector *F* consists of all final absorptions and vector *VA* consists of all value added.

The term $[\mathbf{I}-\mathbf{A}]^{-1}$ is the Leontief inverse of the global input-output matrix. A given element (*ir,jl*) of the Leontief inverse measures the importance of country-industry *ir* as a direct and indirect input supplier to country-industry *jl* in the global economy (see also Carvalho and Tahbaz-Salehi (2019)). To fix a country-industry *ir*'s forward-participation against a specific country *j*, one restricts the final absorption *F* to the segment of the vector corresponding country *j* only (denoted by f_j) and restricts the value added to the segment of the vector corresponding to *ir* (denoted va^r_{ij}):

$$va^r_{ij} = \mathbf{VA}^{-1}[\mathbf{I}-\mathbf{A}]^{-1}f_j \tag{10}$$

$$\tag{11}$$

where va^r_{ij} is a vector of length *J* of the value added of a country-industry *ir* absorbed ultimately by an industry in country *j*, and f_j is a vector of length JxS of the final goods produced by all JxS country-industries *ir* and ultimately absorbed by country *j*. The resulting vector va^r_{ij} measures the value added needed to be generated by country-industry *ir* in order to meet the final demand in country *j*.

To compute a forward participation measure that describes the country-industry *ir*'s exposure to country *j*, we can normalise va^r_{ij} by dividing it either by the total value added produced by *ir*, VA^r_i, or the total industry output of *ir*, Y^r_i, of which a fraction is the industry's own value added and remaining fraction purchases of intermediate inputs, which are the the value added of industries other than *ir*. In the empirical analysis of this paper, the measure is normalised by the total value added produced by *ir*, i.e.:

$$fw^r_{ij} = va^r_{ij}[VA^r_i]^{-1} \tag{12}$$

fw^r_{ij} is a vector of length *S* (number of sectors) of the forward participation rates of country-industry *ir* vis-à-vis country *j*.

The forward participation measure indicates how much an industry exports its value added to other industries, i.e. to what extent an industry is a supplier of goods to other industries. The measure indicates a given EA industry's exposure to country *j* through direct and indirect trade in value added trough its exports. The final destination is fixed to *j=US* and ultimate source is fixed as i = {Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal} for the forward participation measure.

Similarly, the backward participation measure of the country-industry *js* with respect to country *i* is defined as:

$$BW_{ij}^{s} = \frac{\sum_{s=1}^{S} F_{ji}^{sr}}{VA_{j}^{s}} + \frac{\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{s=1}^{S} a_{jk}^{sl} F_{ki}^{lr}}{VA_{j}^{s}} + \frac{\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{s=1}^{S} a_{jk}^{sl} a_{km}^{lt} F_{mi}^{tr}}{VA_{j}^{s}} + \ldots \tag{13}$$

The backward participation measure indicates to what extent an industry imports value added from other industries. The final destination is fixed to j = {Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal} and ultimate source is fixed as *i=US* for the backward participation measure. The measure is normalised with the *importing* (EA) country-industry's total value added, VA_{j}^{s}, to reflect the proportional significance of ultimate US imports from the perspective of the EA industry.

As a measure of an industry's total trade integration through global value chains, one can compute the global value chain participation rate as a sum of the forward- and backward participation measures (see e.g. Georgiadis).

A.2 Upstreamness

I compute the industries' upstreamness measure as:

$$u_{i}^{r} = 1 \times \frac{F_{i}^{r}}{Y_{i}^{r}} + 2 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs} F_{j}^{s}}{Y_{i}^{r}} + 3 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{t=1}^{T}\sum_{k=1}^{K} a_{ij}^{rs} a_{jk}^{st} F_{k}^{t}}{Y_{i}^{r}} + \ldots \tag{14}$$

where $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_{s}^{j}}$, i.e. value added from country-industry *ir* to *js* (Z_{ij}^{rs}) as a share of the *importing* industry's output (Y_{s}^{j}), and $F_{i}^{r} \equiv$ final goods of country-industry *ir*. The upstreamness measure is normalised here by the *exporting* industry's output (Y_{i}^{r}) to adjust for the size of the EA industry. The index can be defined as a value-weighted count of the number of stages that output of an industry passes through, prior to reaching final consumers (Johnson (2018)). The smallest value the index can take is 1 for the final goods sold directly for consumption, inventories or capital accumulation; the larger the value, the further away the value added of the industry is from its final use. Details on the construction of the trade related variables are relegated to the Appendix (Section 5).

Following Johnson (2018), I compute the measure for all country-industry units as:

$$U = 1 \times \mathbf{Y}^{-1} f + 2 \times \mathbf{Y}^{-1}\mathbf{A} f + 3 \times \mathbf{Y}^{-1}\mathbf{A}^{2} f + 4 \times \mathbf{Y}^{-1}\mathbf{A}^{3} f + \ldots \tag{15}$$

$$= \mathbf{Y}^{-1}[\mathbf{I} - \mathbf{A}]^{-2} f \tag{16}$$

where U is a vector of length (JxS) (i.e. 2464x1 matrix), $\mathbf{Y}$ is a (JxS)-by-(JxS) diagonal matrix of the exporting industry's outputs as its diagonal entries, $\mathbf{A}$ is a (JxS)-by-(JxS) matrix with entries a_{ij}^{rs} and f is a vector of length JxS with entries F_{i}^{r} i.e. the final goods produced by the exporting industry.

B Robustness

B.1 Robustness of the main results of Section 3.1.1

The tests here check for the robustness of the main results displayed in figure 2 and 3

B.1.1 Inclusion of lags up to 12 months preceding the shock

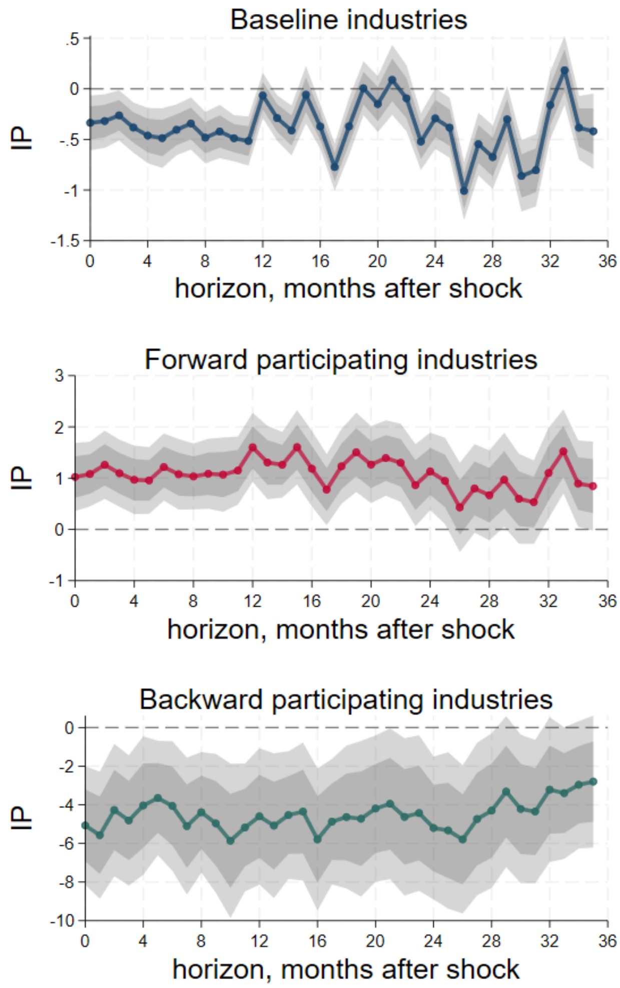

Figure 16: The overall response of EA IP-index to a one standard deviation (positive) Fed monetary shock of 3 bps, with lags of controls up to 12 months before the shock. 68% and 90% confidence bands.

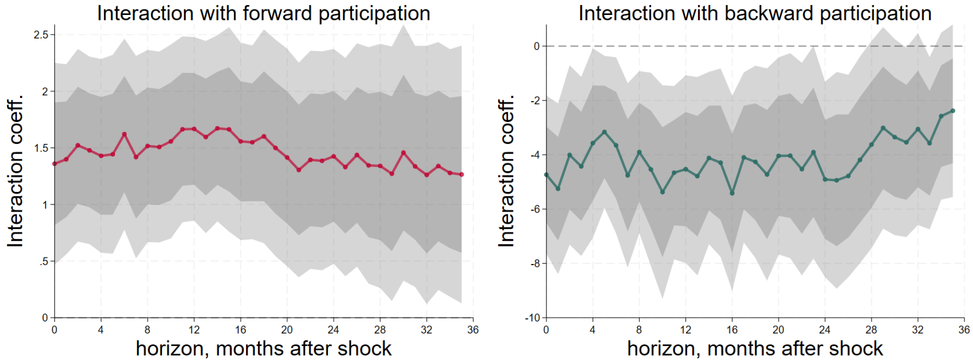

Figure 17: The interaction coefficient in response to a one standard deviation (positive) Fed monetary shock of 3 bps, with lags of controls up to 12 months before the shock. 68% and 90% confidence bands.

B.1.2 Inclusion of country-level and industry-level fixed effects

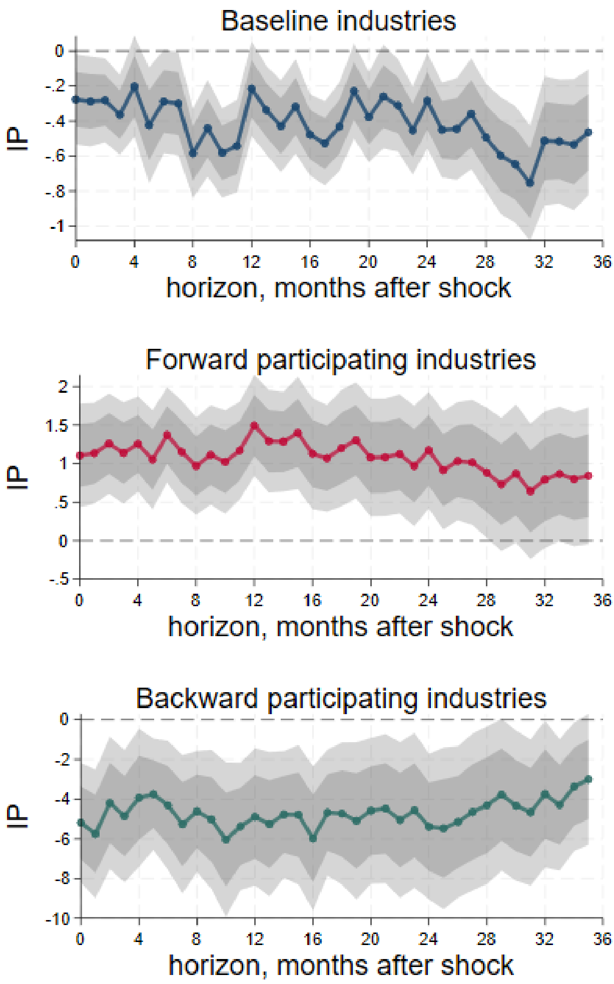

Figure 18: The overall response of EA IP-index to a one standard deviation (positive) Fed monetary shock of 3 bps, with the inclusion of industry-level fixed effects in addition to country fixed effects. 68% and 90% confidence bands.

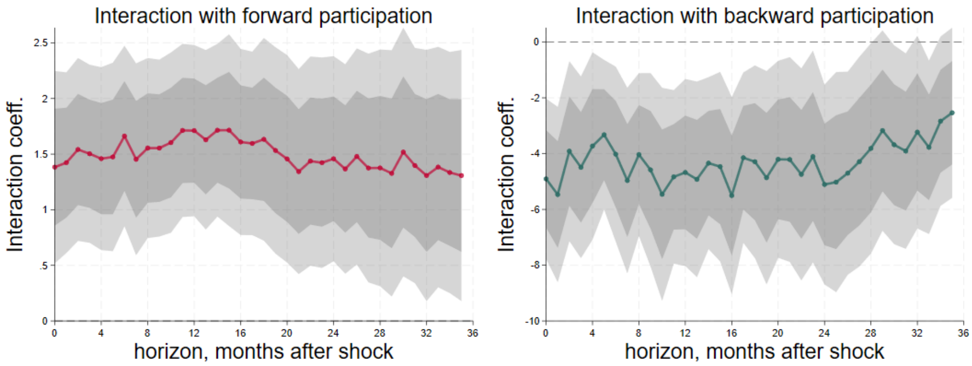

Figure 19: The interaction coefficient in response to a one standard deviation (positive) Fed monetary shock of 3 bps, with the inclusion of industry-level fixed effects in addition to country fixed effects. 68% and 90% confidence bands.

B.1.3 Exclusion of a subset of EA industries with more volatile IP-index

These results are produced excluding certain industries that are in the tails of the distribution on EA industry-level standard deviation of the IP-index. The IP-index used as a dependent variable for the main results of Section 3.1.1 is calendar and seasonally adjusted as well as de-trended. This test is to check whether the results hold when excluding industries that could be generally highly responsive or very little responsive with their production.

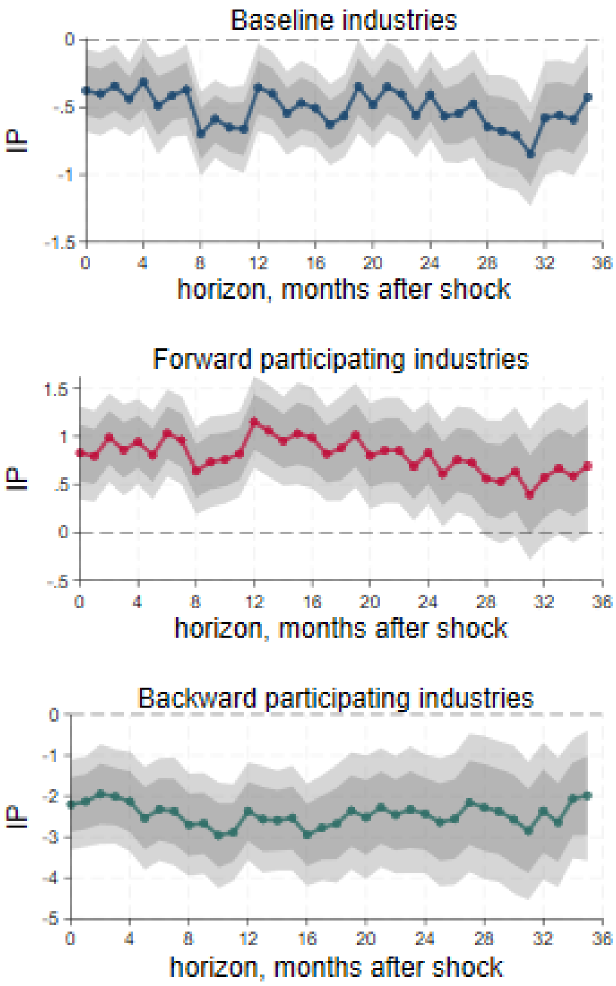

Figure 20: The overall response of EA IP-index to a one standard deviation (positive) Fed monetary shock of 3 bps, with the exclusion of a subset of industries of high and low IP-index standard deviation. 68% and 90% confidence bands.

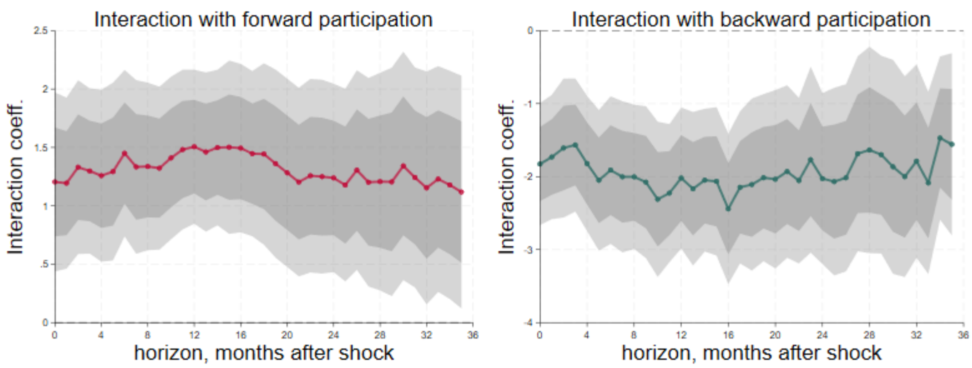

Figure 21: The interaction coefficient in response to a one standard deviation (positive) Fed monetary shock of 3 bps, with the exclusion of a subset of industries of high and low IP-index standard deviation. 68% and 90% confidence bands.

B.2 Robustness of aggregate EA IP-index response to a 'pure monetary shock'

B.2.1 Omission of risk and financial controls

This robustness test is performed re-running the LP model producing 11 including only control variables for EA activity and exhange rate, i.e. EUR/USD FX rate, USD broad value index (against a currency basket of 27 largest US trade partners) and EA real activity index of Scotti (2016) (from a dynamic factor model with EA GDP, industrial production, unemployment, retail sales and purchase managers' index). Lifting the controls representing risk sentiment and financial channels pushes the aggregate EA industrial production response towards negative, but the results are mostly not statistically significant.

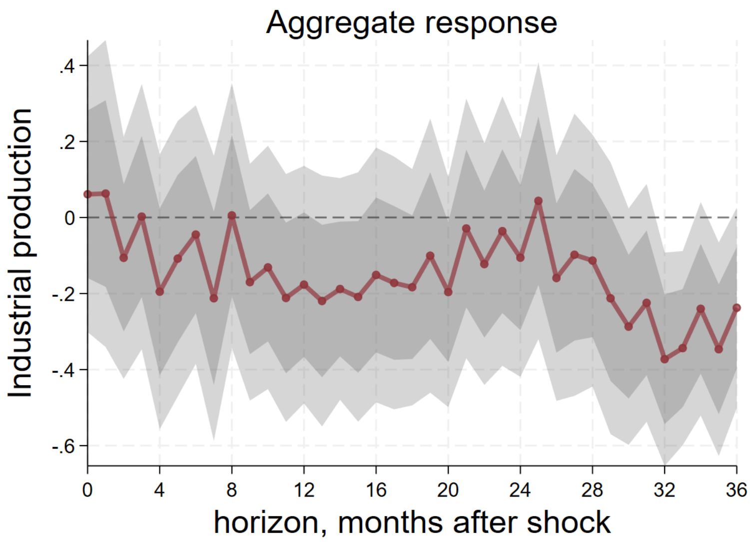

Figure 22: The response of EA IP-index to one standard deviation (positive) Fed monetary shock of 5 bps across all EA country-industry units. LP specification of Section 2.3 **without** variables *bw*, *fw*, *u* or related interaction terms. 68% and 90% confidence bands.

C Data appendix

Table 1: Summary of data for control variables

Variable	Source	Periods	Details
Euro stoxx 50 volatility index	S&P Capital IQ Pro	2000m1-2019m12	Closing value
VIX index	Capital IQ Pro	2000m1-2019m6	
USD broad value index	BIS	2000m1-2019m12	USD value against a basket of 27 main trading partner currencies. Real value, Index, 2020 = 100. Series key: M.R.N.US
Oil price	U.S. Energy Information Administration, retrieved from FRED	2000m1-2019m12	Crude Oil Prices: West Texas Intermediate (WTI)
2-year US Treasury yields	Board of Governors of the Federal Reserve System, retrieved from FRED	2000m1-2019m12	Market Yield on U.S. Treasury Securities at 2-Year Constant Maturity, Quoted on an Investment Basis [DGS2]. Units: Percent, Not Seasonally Adjusted
Eonia	ECB	2000m1-2019m12	Series key: FM.M.U2.EUR.4F.MM.EONIA.HSTA
Excess bond premia	Gilchrist and Zakrajsek (2012)	2000m1-2019m12	
EA monetary policy	Jarocinski and Karadi (2020)	2000m1-2019m12	
EA real activity index	Scotti (2016)	2000m1-2019m12	

Notes: All data are with monthly frequency unless stated otherwise.

Table 2: Summary of data for main variables

Variable	Source	Periods	Details
EA industrial production	Eurostat	2000m1-2017m12	Index, 2010=100. Seasonally and calendar adjusted. Series code: sts_inpr_m.
Fed information shocks	Jarocinski and Karadi (2020)	2000m1-2019m6	Data
Pure Fed monetary shocks	Jarocinski and Karadi (2020)	Data	Data
EUR/USD rate	BIS	2000m1-2019m12	Nominal values; euros per one US dollar.
EA NFC credit spread	Gilchrist and Mojon (2017)	2000m1-2019m12	Credit spread of EA non-financial corporates over the German Bund.
Backward participation	World Input-Output Database (WIOD), Timmer et al.)	2000-2014	Annual data.
Forward participation	World Input-Output Database (WIOD), Timmer et al.)	2000-2014	Annual data.
Upstreamness	World Input-Output Database (WIOD), Timmer et al.)	2000-2014	Annual data.
EA capital good import price	Eurostat	2005m1-2019m12	Import price index (from outside EA) for 20 EA member states. MIG Capital Goods Industry - NACE Rev.2. Accessed via ECB. Series key: STS.M.I9.N.IMPX.NS0050.4.000
EA manufacturing good import price	Eurostat	2005m1-2019m12	Import price index (from outside EA) for 20 EA member states. MIG Manufacturing Goods Industry - NACE Rev.2. Accessed via ECB. Series key: STS.M.I9.N.IMPX.2C0000.4.000
EA intermediate good import price	Eurostat	2005m1-2019m12	Import price index (from outside EA) for 20 EA member states. MIG Intermediate Goods Industry - NACE Rev.2. Accessed via ECB. Series key: STS.M.I9.N.IMPX.NS0040.4.000
Global Price Index of All Commodities	IMF	2003m1-2019m12	Index with prices for all commodities in IMF database. Basis year 2016=100. Code PALLFNFINDEXM.
US net imports (deflated gross imports minus deflated gross exports)	U.S. Census Bureau and U.S. Bureau of Economic Analysis (retrieved from FRED)	2005m1-2019m12	Exports of Goods and Services, Balance of Payments Basis [BOPTEXP]; Imports of Goods: Balance of Payments Basis [BOPGIMP]. Deflator: Personal consumption expenditures: Market-based (chain-type price index) [DPCMRG3M086SBEA]. Index 2017=100. All seasonally adjusted.
US real activity index	Scotti (2016)	2000m1-2019m12	Built from a dynamic factor model with US GDP, industrial production, non- agricultural payrolls, retail sales, the ISM manufacturing index and personal income)

Notes: All data are with monthly frequency unless stated otherwise.