The International Transmission of the Fed Information Effects: Evidence from Europe

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Abstract

When the Fed signals a booming US economy, part of Europe catches a cold – part of it thrives. This paper asks how an upswing in the US business cycle transmits to the Euro Area through trade. I study the question empirically through panel local projections that exploit EA industries' asymmetric input-output linkages with the US economy. These linkages prove decisive for the international propagation of US upturns, often obscured in aggregate responses. The analysis reveals asymmetric spillovers to the Euro Area from a US demand shock that can be interpreted as macroeconomic news released by the Federal Reserve. The good news about the US economy foretell a two-speed economy for Europe: industries that ultimately export to the United States move in step with the US business cycle, while those that import from the US contract as adverse global price and exchange rate movements pass the US demand shock downstream as a cost-push shock. Expenditure-switching effects contribute but cannot fully explain the observed pattern in US import demand. In contrast, monetary tightening by the Fed exerts contractionary effects on Euro Area aggregate activity with weaker dependence on trade linkages than the Fed's information effects. The empirical evidence motivate a theoretical two-country model that replicates the qualitative patterns observed in the data.

JEL Codes: E44, E52, E58, F44.

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1 Introduction

In this paper, I study empirically and theoretically how demand shocks originating in the US affect European industries. I identify such foreign demand shocks through the Fed's 'information effect' and then study how they propagate through the global production network to European firms. My analysis thus has implications for both the credibility of identified Fed information shocks as plausible signals of forthcoming US economic expansions and for the channels by which foreign demand shocks propagate through trade networks. My empirical findings are consistent with the theory on both fronts. First, Fed information shocks act like foreign demand shocks, boosting foreign sales while increasing the cost of imported inputs. With this I bring forth new evidence on the capacity of central bank information effects to stir responses in the real economy, from an international macroeconomic point of view. Second, the shocks affect European firms differently depending on their position in the network: upstream firms benefit from higher demand and expand, while downstream firms suffer from greater costs (notably energy costs) and contract. The Euro Area moves towards a two-speed economy as industries' business cycles diverge.

I study the case of the Euro Area as a recipient of positive news about the US business cycle, conveyed by the US Federal Reserve. First, the data on the Fed's policy actions and announcements are arguably the most abundant and scrutinised information available on such 'informational' central bank policies. Second, the United States and the Euro Area have a deep and longstanding economic relationship that has intertwined the two economies together, despite a periodic reconfiguration. The Euro Area, being a large, open and advanced economy, therefore has rich heterogeneity in its trade links with the US economy, in addition to a large financial system, compared to e.g. emerging economies and small open economies whose trade links and financial links with the US go more tightly hand-in-hand. Because of the United States' centrality, a turn in its business cycle quickly has a global reach that ripples through production networks and global market places. This paper brings forth new evidence on the asymmetric trade exposure of the Euro Area economy to the spillovers of a US economic expansion. On the aggregate, a positive US demand shock stimulates European real activity. Yet, these *aggregate benign* effects on EA production mask vastly divergent patterns depending on the industry's input-output linkages to the US economy.

Is a booming US economy good and bad news for European activity? This question can be answered conditioning on the type of boom we extract, here identified through the central bank's communication policies. This paper demonstrates that the US expansion is both a positive demand shock for European industries supplying the US economy via global value chains – and an adverse cost-push shock to the European industries relying on imported inputs ultimately from the United States. The literature traditionally models demand shocks to travel *upstream* in value chains, from customer to supplier. The results shown here quantify the relevance of the channel in which US demand shock is also being passed on *downstream* via marginal cost increases to the extent prices are adjustable. Most EA industries benefit from a US upturn; either directly via higher demanded quantities along the value chain, or through exchange rate movements

that lift even the EA industries that are not particularly trade-linked to the US economy. Notwithstanding, the downstream quarter who experience the adverse effects contract their output by twice as much as the upstream winners of the US expansion. An untamed US import demand is the likely culprit for the 'downstream penalty'. The US economy tends towards a trade deficit when it booms and doing so it raises global demand – prices for internationally traded goods rise, implying that the world supply of these goods cannot meet the higher US absorption. Consequently, the EA industries who source their imported inputs ultimately from the United States find themselves competing in global production networks for scarcer production inputs that are being absorbed by an expanding US economy. This sends the EA industries that are input-linked to the US economy on a downward trajectory, opposite of the EA exporters.

These dynamics are reinforced by the exchange rate response to the expansionary US demand shock; after a short-lived depreciation of the dollar against the euro, the USD overall appreciates in response to positive news on the US economic outlook. While the expenditure-switching effects of an appreciated dollar contribute to the disparity among the EA industries, they cannot account for the observed patterns on their own without the underlying wealth effects that arise from an expanding US economy that stimulates US import demand. This challenges the traditional Mundell-Fleming economy view, where exchange rate movements are the dominant force of international trade flows. The findings emphasise the importance of the US wealth effects for the US demand shock transmission, in a similar vein with Christiano et al. (2025) who attribute US imports' response for most of the international transmission US monetary policy.

The analysis obviously overlooks other relevant channels of transmission, a major one being the financial channel. Previous literature has gathered robust evidence on the existence of international financial channels of Fed (monetary) policies (Rey (2013); Miranda-Agrippino and Rey (2020)), and for the emerging markets in particular (Kalemli-Özcan (2019)). This paper departs from most of the current literature on the transmission of Fed policies, as the foreign demand shock under study is not the traditional monetary policy shock that can be thought of as an innovation to the central bank's Taylor rule – i.e. an interest rate shock. Instead, the Fed news shock is a 'C* shock' from the perspective of the 'Home economy', the Euro Area. In theory, the positive news about the US economy emitted by the Fed imply a higher US consumption (a higher C*), which translates into higher global demand for goods. The Fed news shock therefore represents a shock on C* more directly compared to an interest rate shock. A policy rate shock on the other hand would affect US consumption indirectly by exerting financial influence, entering into the economy through the interbank market, and subsequently dampening activity through financial and nominal frictions.

While the main focus is on the Fed news as foreign demand shocks, I also contrast the transmission of the Fed news shock with other US business cycle shocks, including the 'pure' Fed monetary shock by putting these shocks inside the same methodological framework. Contrary to the transmission of the positive news shock – which pushes expenditure-switching and -augmenting effects in the same direction – in the case of monetary policy shock the two channels should exert opposite influences; the dollar again appreciates,

although US demand softens. The Fed's monetary tightening shock also travels through the direct demand channel of lower demanded quantities, affecting in particular the exports-exposed EA industries: these industries contract their output when the Fed tames US demand via tighter policy. Again, with the exporters being less sensitive to the exchange rate channel, the dollar appreciation is unable to offset the slump in their activity and the EA exporters follow the trajectory of US business cycle. On the contrary, the US monetary policy shock appears to exert offsetting pressures on EA ultimate importers who are more sensitive to changes in international prices and exchange rates. These industries benefit from lower costs of imported inputs as US demand for them curtails. At the same time, higher import prices in euro terms exert dampening effect on these industries as the dollar appreciates with US monetary tightening. Empirically, the US monetary tightening shock's effect on EA import-exposed industries is therefore close to net zero.

The results described above come from both a reduced form analysis applying panel local projections as well as a structural open economy model. In the panel local projections the Fed shocks are interacted with network-based measures on the EA industries' trade exposure to the US economy (Antras and Chor (2022), Johnson (2018)), Carvalho and Tahbaz-Salehi (2019)). The Fed shock series are taken from Jarocinski and Karadi (2020), whose monetary policy shock series are widely used in the empirical macro literature. The authors identify the shocks from high-frequency financial asset price movements, resorting to the ability of the stock markets to distill news about the US economy from the Fed's actions. The evidence that the Fed news shocks unravel in the global macroeconomy as we would predict by the very short-term financial asset price movements lends credence to the identification approach through high-frequency equity market movements. This bears a wider message regarding the Fed's policy toolkit; *on occasions of a particularly strong economic signal*[1] markets appear to read the Fed's signals correctly and act on them. The ability of a credible central bank to align the markets' economic views with its own, especially in times of uncertainty, may prove a valuable policy tool (Falck et al. (2021)).

The empirical patterns are rationalised through a theoretical open economy model, a two-country New-Keynesian model of the United States and the Euro Area, featuring representative agents and incomplete asset markets. The model fits qualitatively the observed empirical responses in (i) EA importers' and exporters' production, (ii) the exchange rate and (iii) the US trade balance. The model is kept deliberately stylised in order to provide a fairly tractable framework in terms of which we can think of the observed empirical patterns, with no counterfactual exercises being run that would require a fully quantitative model. The model exhibits, in its simplest form, upstream propagation of demand (Ozdagli and Weber (2017); di Giovanni and Hale (2021)) – from the US tradable firm to the EA exporting firm – as well as downstream propagation of marginal costs subject to price rigidity – from the US tradable firm to the EA importing firm. The model structures the US-EA trade relations such that a US consumption boom will exert both upward and downward pressures on European production, as observed empirically, with the EA downstream sectors

[1] The Fed news shocks studied here come from particularly strong signals to the public in circumstances where equity prices and interest rate futures co-move, such that monetary action does not offset the underlying signal.

eventually having to compete for a limited global supply of resources being absorbed by the US consumer. When the US economy accelerates, the EA exporter output rises as it supplies the growing US tradable sector, while the EA importer contracts along with higher US intermediate input prices and an appreciated dollar, both making imports from the US tradable more expensive.

The model explains the empirical US dollar pattern – initial short-lived depreciation, subsequent appreciation – by the countering forces of inflation and consumption differentials between the EA and the US. When a US demand shock hits, consumption in the US jumps up while EA consumption drops; an expected mean-reversion of the consumption differential exerts short-lived depreciation pressure on the dollar. Prices respond more slowly. As inflation in the US gradually picks up and the US-EA inflation differential grows, it requires an expected dollar appreciation to compensate the EA household for holding the USD-denominated nominal bond. This force is the dominant one in the model simulations for the EUR-USD exchange rate response. Lastly, the US economy moves towards a trade deficit when it expands, since the imports-intensive US tradable sector scales up its production (scale effect) and becomes increasingly imports-intensive with more of its output directed towards absorption in the domestic economy (composition effect). The US-issued bond holdings that finance the US trade deficit are enabled by increased returns from higher US interest rates and expected dollar appreciation, which compensate the EA household for making way for growth in US consumption.

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 signalling effects, which it draws on. The Fed has been pointed out as a source of global shocks (e.g. in Rey (2013); Dedola et al. (2017); Iacoviello and Navarro (2019); Kalemli-Özcan (2019), Degasperi et al. (2023); Christiano et al. (2025)). Shedding light on the role of the Fed information effects as global demand shocks offers a new analytical perspective on the classical question of the international transmission of US monetary policy, complementing a large body of research on the identification of the Fed's information effects (e.g. Romer and Romer (2000); Campbell et al. (2012); Gertler and Karadi (2015); Melosi (2017); Nakamura and Steinsson (2018); Cieslak and Schrimpf (2019); Jarocinski and Karadi (2020); Andrade and Ferroni (2021); Bauer and Swanson (2023); Miranda-Agrippino and Ricco (2021); Aruoba and Drechsel (Forthcoming)). Empirical research featuring policy shock propagation in production networks include Ozdagli and Weber (2017), di Giovanni and Hale (2021), Ghassibe (2021); di Giovanni and Rogers (2022) and Nakov and Ghassibe (2025). These papers mainly pertain to monetary policy shocks.

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 (2023) 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 ('Fed response to news' channel), 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. The recent papers of Jarociński and Karadi (2025) and Ricco and Savini (2025) evaluate both the 'information channel' and 'Fed response to news' hypotheses and find varying degree of support for both.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.

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 aggregate output, but for the domestic economy. 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 activity. My paper contributes to this body of evidence documenting a more nuanced effect depending on the industry's trade exposure vis-à-vis the US.

The paper proceeds as follows. Section 2 outlines the empirical strategy and data. Empirical results are presented in Section 3. Section 4 discusses the findings which is followed by Section 5 that fits the reduced form patterns in a stylised theoretical model. Section 6 concludes.

2 Empirical strategy

The main empirical analyses of this paper 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). Local projections have the advantage of being readily applicable to a panel setting. The estimation methodology exploits both between- and within-industry variation; the time dimension of the panel allows estimating the dynamic effects of the shock transmission, while the cross sectional variation in the time-fixed trade-related variables (backward and forward participation) provide information on how these industry-

level features matter for the response to the central bank shock, which I capture by including interaction terms of the shock with the trade-related variables. The external identification of the shocks grants not having to restrict the coefficients of the impulse response functions further from the original central bank shock identification scheme that relies on sign restrictions. This section first describes the key variables of the empirical model which is specified at the end of the section.

2.1 The central bank shocks

The Fed shocks of Jarocinski and Karadi (2020) have become part of the standard toolkit of empirical macroeconomists, making them an object of interest for this paper. The identification strategy relies on stock price reactions during the FOMC announcements to disentangle the two 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. The interest rate surprises are measured from the three-month federal 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. As such, the surprises involve the effect of actual policy rate changes as well as the very near-term forward guidance. The interest rate surprises are originally from the Gürkaynak et al. (2005) database and are measured in a time window starting 10 minutes before the announcement and ending 20 minutes after, adjusted from the original paper to reflect also the Fed press conferences. 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)).

The Fed shock classification scheme of Jarocinski and Karadi (2020) relies on the observation that often the equity market response to monetary tightening runs counter to the standard textbook intuition of the demand dampening effect of monetary policy: occasionally monetary policy tightening leads to an *appreciation* of stock prices. This could be rationalised by the theory of the central bank information channel; along with its tightening the central bank may release signals about its confidence in the economy which the markets learn about. 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 investor receiving simultaneously the two *countering signals* that accompany Fed information shocks, one towards a stock price rise (given the positive economic outlook) and another towards a stock price fall (given the 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 news about economic fundamentals based on stock

price reactions could be just a residual component of the HFI monetary policy shocks that bears no clear significance for economic outcomes. Arguably, stock prices are devisive for the identification of the shock type as equity valuation has a clear theoretical link to corporate performance and thus also to the state of the macroeconomy. Moreover, stock prices can be measured at a high frequency, as are the interest rate changes within the monetary announcement window. 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, stock price movements may produce noisy signals about the public's interpretation of the central bank announcements, which calls into question whether the outcomes in the real economy will eventually match our readings of the high-frequency stock market movements during 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 (2023) 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 the Fed announcements derives from another form of information misalignment between the central bank and markets on how macroeconomic news be translated into interest rate changes. The bottom line is that the stock repricing during monetary announcements is associated with the arrival of new macroeconomic information and indicative of the markets' perception of changes in the underlying aggregate economy under the hypothesis that there is a strong link between the real economy and equity valuation.

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. The trade exposure to the US economy is measured through the industry's 'forward participation' and 'backward participation'. 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 noting that almost half of global trade today involves global value chains and thus indirect trade in value added (World Bank (2020)). Hence, not accounting for indirect trade likely leaves us with an incomplete understanding of the EA trade exposure. Considering the role of the United States and its central bank in the global economy, indirect trade is included in the analysis such that spilled over US demand that propagate to the euro area via 'third countries', is accounted for.

The WIOD data used to construct the trade related variables are annual, and the measures constructed using the WIOD data (industry's backward and forward participation) 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. It therefore seems to be the case that the industry's relative trade exposure vis-à-vis the US are rather structural features of the industries that do not fluctuate much over the maximum time period considered in the empirical analysis (2000-2019) at the industry-level of aggregation.[2] 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.

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 countries *m,k* and industries *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 country-industry *kl*, as a share of the *importing* industry's output, (Y_{k}^{l}), and $F_{ij}^{rs} \equiv$ final goods produced in country-industry *ir* and absorbed in country-industry *js*.

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, which makes it a measure of 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. 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 such that the measure 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.

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

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

[2] Some of these trade links that are considered structural until end-2019 may have changed after 2019, by either being temporarily disrupted during the Covid-19 pandemic or by becoming permanently severed in geopolitically motivated reorganisation of trade relations.

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. Details of the construction of these trade exposure measures are relegated into the Appendix A.1.

As the interest ultimately lies in studying the impact of the Fed shock under a *strong one-sided trade exposure* of the EA industry to the US economy, dummies are created based on the top-quartile of the industry distribution of a given trade related variable (backward or forward participation), separating the heavily imports or exports exposed EA industries into their own categories. The dummies serve the purpose of utilising the industries' asymmetric input-output linkages to describe the nature of the given Fed shock, which should represent a demand shock of a positive or negative sign (or potentially neither). Hence, I compare the top-25% most forward and most backward participating industries vis-à-vis the US against the rest, since these industries are very exposed to the US either via exports or via imports (relative to the rest of EA industries), making them likely to experience the Fed shock distinctly given this feature.

2.3 The main panel local projection specification

The main local projection (LP) model is a series of regressions run for different horizons $h = 0, 1, \dots, H$ of the form:

$$\begin{aligned} x_{t+h,ir} - x_{t-1,ir} = \beta_h^{\epsilon}\epsilon_t + \beta_h^{fw} fw_{ir} + \beta_h^{bw} bw_{ir} + \phi_h^{fw}\{fw_{ir}\epsilon_t\} + \phi_h^{bw}\{bw_{ir}\epsilon_t\}\dots \\ + \psi_{sh}' \boldsymbol{z}_{s,t,ir} + \tau_{h,ir} + \eta_{t+h,r}, \end{aligned} \tag{3}$$

where t indexes time, ir indexes a country-industry pair, s indexes the lag, $x_{t+h,ir} \equiv$ the industry outcome variable of interest at horizon h, $\epsilon \equiv$ the Fed shock of interest, $bw \equiv$ backward participation dummy, $fw \equiv$ forward participation dummy, $\boldsymbol{z} \equiv$ a vector of control variables, including linear, quadratic and cubic trends, $\tau_{h,ir} \equiv$ country-industry fixed effects and $\eta_{t+h,r} \equiv$ the residual.

The industry outcome variable of interest is the EA industrial production index (IP-index), which describes the EA industry-level real economic performance. The control variables comprise: (i) Euro Stoxx 50 volatility index, (ii) Eonia-rate, (iii) EA non-financial corporate credit spreads of Gilchrist and Mojon (2017), (iv) EA industrial confidence, (v) EA real activity factor of Scotti (2016), as well as lagged values of the dependent variable and the shock, all variables with lags of up to 6 months prior to the shock's occurrence. The focus of the paper is on the transmission of the Fed information shocks through real trade linkages, which is the rationale for including Euro Stoxx 50 volatility index, Eonia-rate and EA non-financial corporate credit spreads as controls that represent the transmission of Fed shocks through risk sentiment and financial channels (such as the 'global financial cycle'-type of effects proposed by Miranda-Agrippino and Rey (2020)). Controls are also included to address potential reverse causality from euro area driven demand

reflected in the Fed shocks by adding the EA macroeconomic variables: EA industrial confidence and EA real activity index of Scotti (2016) (constructed from a dynamic factor model involving EA GDP, industrial production, unemployment, retail sales and purchase managers' index). The Eonia rate was the main overnight interbank lending rate in the EA during the time period covered, and as such it serves to control also for both endogenous and exogenous components of the EA monetary policy.

The time dimension spans from 2000m1 to 2019m12 and the frequency is monthly. The time span therefore includes some of the period of trade wars and tariffs set between the US and EU starting from 2018 during the Trump presidency in the United States. Robustness tests show that the main results are not sensitive to excluding this period. The empirical analysis is not extended beyond end-2019 considering that the Covid-19 pandemic and the related supply chain disruptions likely severely affected the trade links under study.

The industries in the sample are from the initial 12 euro area countries[3]. These countries have been part of the euro area since its inception, which simplifies addressing the monetary policy and exchange rate regimes that affected these countries in the sample period. Given that the macroeconomic conditions of this set of EA countries have differed substantially and potentially affected the response to the US shocks, country-level fixed effects are included. Robustness tests show that the main results are not sensitive to the inclusion of both country and industry-level fixed effects. The number of industries from this set of countries for which IP-index data is available amounts to 218 country-industry units. The data for the IP-index covers mainly manufacturing industries. The volatility of the IP-index differs across the industries. To ensure that the results are not driven by excessively or inadequately volatile industrial production at the industry level, outliers are excluded based on the industry-level standard deviation of the IP-index, by cropping the 1%-tails of the cross-sectional distribution of industries' IP-index standard deviation. Removing a total of six outlier industries from the sample results in a number of industries included in the analysis equal to 212. Robustness test of the Appendix reports the main results when no outliers are excluded from the sample.

Local projection 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 of the panel LP there is a possibility 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).

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

3 Empirical results

3.1 Aggregate Euro Area response to Fed news and monetary shocks

The empirical results presented in this section demonstrate how the Fed news shocks identified from high-frequency financial data translate into real economic effects at the international level. On the aggregate, the effect of the positive Fed news (left) goes in the opposite direction of a theory-predicted response to a 'pure' monetary policy shock (right, Figure 1). The adverse aggregate effect of the US monetary policy shock is in line with what we would predict based on the demand dampening effects of monetary policy on the US economy, for foreign and domestic goods alike. Given the real activity boosting effect of the Fed news shock on the one hand, and the dampening effect of the monetary shock on the other, the aggregate results largely cross-validate the results of Jarociński (2022) which document opposing effects of these two Fed shocks on the EA gross domestic product.

As shown in the next section, this aggregate view has little to say about how half of the EA industries experience the US business cycle upturn (Figure 2; middle and right panel) and what is the propagation mechanism of the US expansion into EA activity. As it turns out, the aggregate picture across all EA industries masks vast underlying heterogeneity in how EA industries experience the Fed information effects. With asymmetric input-output linkages, a booming US economy is good news for some and bad news for others. This becomes evident in Figure 2 which breaks down the response to the positive Fed news shock by the EA industries' asymmetric trade exposures to the US economy.

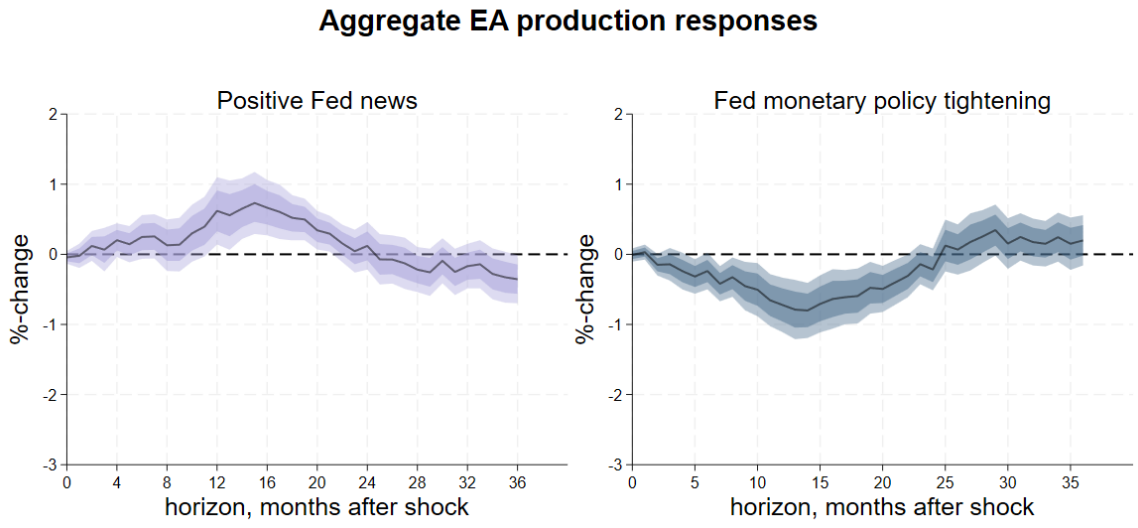


Figure 1: The average response of EA IP-index to one standard deviation positive Fed news shock of 3 bps (left) and to one standard deviation Fed monetary tightening shock of 5 bps (right) across all EA country-industry units. LP specification of Section 2.3 without interaction terms. 68% and 90% confidence bands.

3.2 Fed news shocks

3.2.1 Main results: Fed news shocks

Figure 2 shows the overall response (i.e. to the main effect of the shock and its interaction term) 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, right 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). The responses are to a Fed news shock that is scaled to one standard deviation positive shock (throughout the paper), which represents an upturn in the US business cycle.

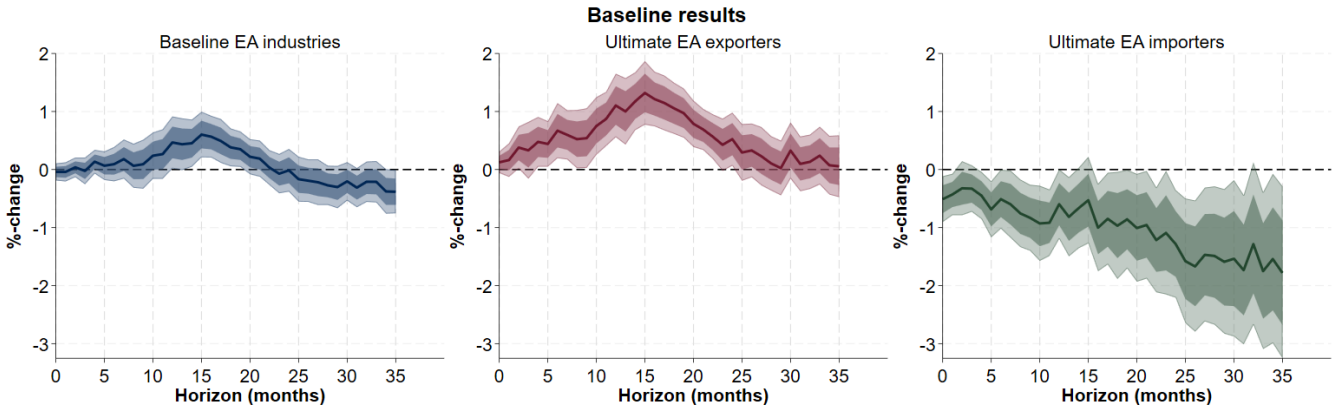


Figure 2: The overall response of EA IP-index to one standard deviation positive Fed news shock of 3 bps. The overall effects comprise the main effect and interaction terms, i.e. $\beta_h^e + \phi_h$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

The left panel of Figure 2 shows the effect of the shock on the EA industries that are not particularly exposed to the US economy through trade. These baseline industries' response to the Fed news shock largely follows the pattern of the aggregate response (Figure 1). Noteworthy – a comparison of the right and middle panels of Figure 2 shows us that the Fed news shock has the opposite effects on the exporting and importing EA industries' real activity, as it expands the production of ultimate exporters and curtails the production of ultimate importers, contrary to the aggregate effects. The ultimate EA importers' production falls on impact from the shock's occurrence and continues to fall over the course of the following three years from the Fed announcement. At the trough these industries' production falls on average around 2%. The adverse effect of the shock on this group of industries could be the outcome of adverse exchange rate movements as well as having to compete (against the US firms or globally) with greater demand for inputs as the US economy booms, consistently with the price effects of the shock reported below in Section 3.2.2. In the middle panel we see that the impact of the Fed news shock on the ultimate exporters at the EA goes in the opposite direction; the effects materialise gradually for these industries, increasing their production on average by 1% at the peak, likely as a result of higher exports driven by higher global demand. The boosting effect on the ultimate EA exporters dissipates after about two years from the shock's occurrence. The responses of both

groups are statistically significant at the 90% confidence level nearly throughout the time horizon of three years.

The differential effect of the Fed news shock becomes apparent also from the coefficients of the interaction terms alone, between the given trade-exposure variable and the Fed news shock (Figure 3). Following the Fed information shock, forward participating EA industries experience an additional boost of up to 0.75% on average by belonging to the group of most exports-exposed industries, while imports-exposed industries experience an offsetting production drop of up to 1-1.5% on average from the main effect.

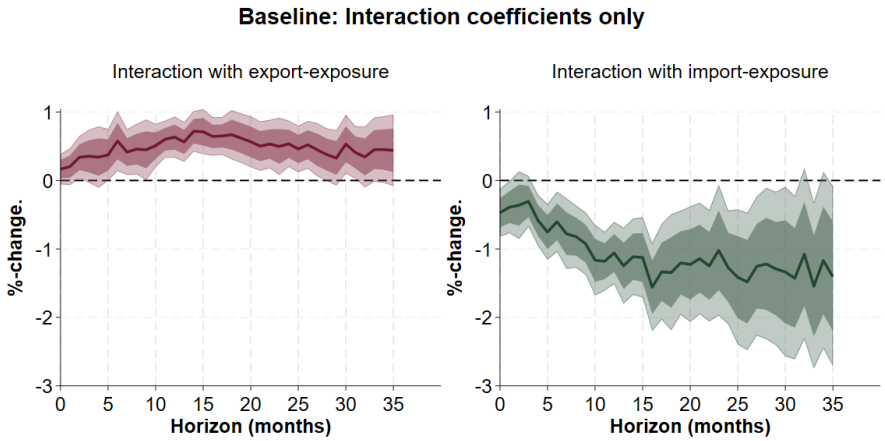


Figure 3: Interaction coefficients of the forward participation dummy (left) and backward participation dummy (right) with the Fed information shock, which is ϕ_h^i, $i \in \{fw, bw\}$ in the LP model of Section 2.3. The response of IP-index is scaled to one standard deviation positive Fed information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

A key message of the results above is the substantial heterogeneity in the response among EA industries that have the opposite input-output linkages with the US economy; input-linked EA industries receive relatively much of their inputs (ultimately) from the US while the opposite holds for the EA ultimate exporters. 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). The results demonstrate the advantage of studying the effects of the Fed news shocks through international data that allow studying the effects conditional on asymmetric input-output linkages. Utilising the distinct, one-sided, exposure to the US economy that foreign industries exhibit is likely to clear much of the ambiguity arising from input-output linkages, which lead aggregate effects to either understate the impact on some industries (ultimate exporters to the US) or even predict effects that go in the opposite direction (as in the case of the ultimate importers to the US). The responses we observe among European industries are symptomatic to higher demand in the US economy for foreign goods, observable in the US external trade balance in Figure 4; it shows that both US exports and imports rise, with the US demand from the world notably rising passed the increased supply to the world, which suggest that when the US accelerates, the country also tends towards a trade deficit.

The results shown here do not tell us whether the demand stems from changes in exchange rates or a general rise in US demand for goods, stemming from an upturn in the US business cycle augmenting its

expenditure. Indeed, the findings presented above are consistent with a depreciation of the euro against the dollar, benefiting EA exporters and harming EA importers, with European goods becoming cheaper in US dollar terms and dollar priced goods becoming more expensive in euro terms under producer currency pricing. In the limit, the observed real effects could be induced completely by expenditure-switching effects of exchange rate fluctuations, without an underlying benign US business cycle conditions that the Fed news shock is taken to represent. The next section reassesses the Fed information effects controlling for the path of the broad dollar value and the EUR/USD-exchange rate, showing that, while expenditure-switching effects are present, they by no means account for the full effect of the shock on European production.

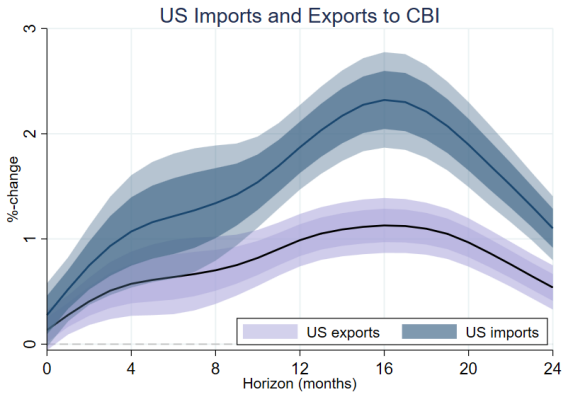


Figure 4: The response of real US imports and exports to one standard deviation positive Fed news shock of 3 bps. Vertical axis: change in net imports estimating $y_{t+h} - y_{t-1} = \alpha_h + \beta_h^{\epsilon}\epsilon_t + \mathbf{z}'_{t-j}\psi_h + \eta_{t+h}$ where $\boldsymbol{z} \equiv$ a vector of controls: lagged values of the dependent variable up to 6 months prior to shock; linear, quadratic and cubic trends; monthly dummies for seasonal effects. 68% and 90% confidence bands.

3.2.2 The exchange rate and price effects

The Fed news shock is likely to affect the EA industrial production through the exchange rate channel, which has been emphasised in the traditional open economy literature. The channel works through expenditure diversion 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 positive Fed information shock, by running lag-augmented smooth local projections with the EUR/USD-rate as the dependent variable. This shows that, overall, the US dollar tends to appreciate as a result of the Fed news shock (Figure 5), after a short-lived depreciation immediately after the Fed information event. The pattern of a brief depreciation followed by a longer term appreciation of USD against other advanced-economy currencies is also documented in Georgiadis and Jarocinski (2023) who rationalise the on-impact dollar depreciation by a risk-on sentiment following positive Fed information shocks. The dollar appreciation is precisely in line with the observed 'boost for EA exporters – penalty for EA importers'- pattern that the last section documented. This section resimulates the effect of the positive Fed news shock in the same model specified in Section 2.3, but controlling for the path of broad dollar value and the bilateral EUR/USD-exchange rate; I include as controls: (i) the bilateral USD-EUR exchange rate; (ii) the dollar value against a currency basket of 27 main US trading

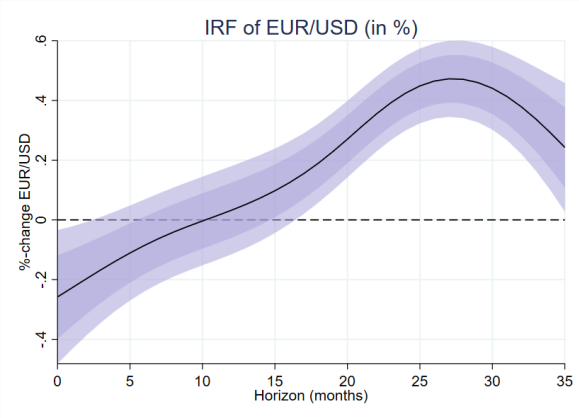


Figure 5: The EUR/USD rate response to one standard deviation positive Fed news shock. The FX rate is defined as euros per dollar, hence an increase in value means dollar appreciation. Controls include lagged values of the dependent variable up to 6 months prior to shock; linear, quadratic and cubic trends; monthly dummies for seasonal effects. 68% and 90% confidence bands.

partner currencies (both with the standard of six months of lagged values); as well as interaction terms for (iii) the EUR/USD-rate with the backward participation and (iv) the EUR/USD-rate with the forward participation, in order to account for a differential response to exchange rates among ultimate US exporters and importers.

The results in Figure 6 demonstrate that expenditure switching effects do play a role for the responses of EA industries to the Fed news shock; the magnitudes of the effect are muted from those of the main results (Figures 2 and 3), such that EA exporters (middle) benefit less from a US upturn once the boosting effect of euro depreciation is addressed. The baseline group (left) becomes virtually unaffected by the Fed information shock, in line with the lack of trade links with the US and, here, with a lack of exchange rate exposure. The effects on the EA importing industries are quite notable; the harmful effect of US expansion is reduced by about a half of its baseline result, and the importers now show signs of a rebound towards the end of the three-year horizon.

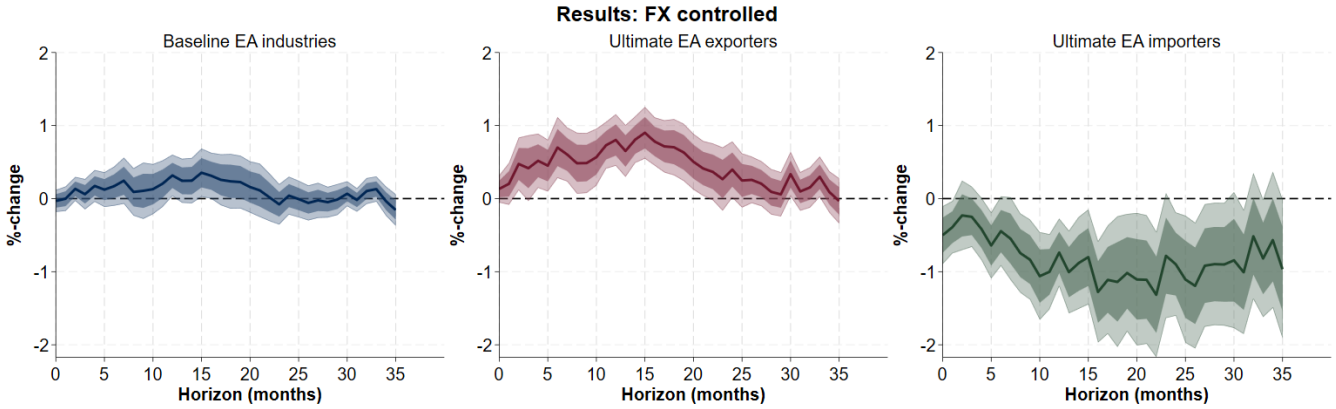


Figure 6: The overall response of EA IP-index to one standard deviation positive Fed news shock, controlling for broad dollar value and bilateral EUR-USD FX rate. The overall effects comprise main effect and interaction terms, i.e. $\beta_h^{\epsilon} + \phi_h$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

The main take-away of Figure 6 is that even after addressing the exchange rate's influence, the bulk of

the effects remain and the results stay statistically significant. This leaves a substantial proportion of the (positive) Fed news shock's influence on foreign trade partners attributable to the expenditure-*augmenting* effects of changed incomes, cash flows and expenditures in the US that reflect benign US business cycle conditions and resulting demand for foreign goods. This is noteworthy as it is informative about the nature of the Fed news shocks; the US stock market response to the Fed announcement does not appear to solely represent financial side movements, such as exchange rate fluctuations, which would drive real effects through expenditure switching alone, without positive underlying economic conditions in the United States. On the contrary, the results above lend support to the presence of both income and expenditure switching effects of the Fed news shocks.

Turning to the price effects, the Fed news shock manifests itself in international prices as measured by global commodity prices (Figure 7) and the prices of EA imports from outside the EA (Figure 8). 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 for extra-EA import prices i.e. prices that European firms pay for their imports globally. In line with the higher global demand arising from the US (Figure 4), the US economic expansion raises EA import prices across a wide categories of production inputs.

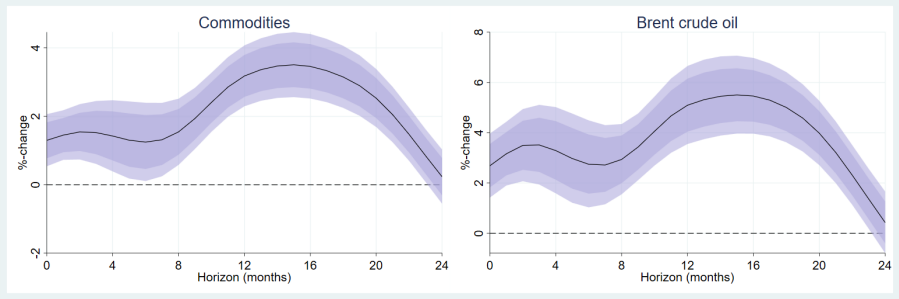


Figure 7: Global commodity price responses to one standard deviation positive Fed news shock of 3 bps. Vertical axis: %-change in the price index estimating $y_{t+h} - y_{t-1} = \alpha_h + \beta^{\epsilon}_h \epsilon_t + \mathbf{z}'_{t-j}\psi_h + \eta_{t+h}$ where $\boldsymbol{z} \equiv$ a vector of controls (6 lagged values of the dependent variable and the shock; linear, quadratic and cubic trends; monthly dummies for seasonal effects). 68% and 90% confidence bands.

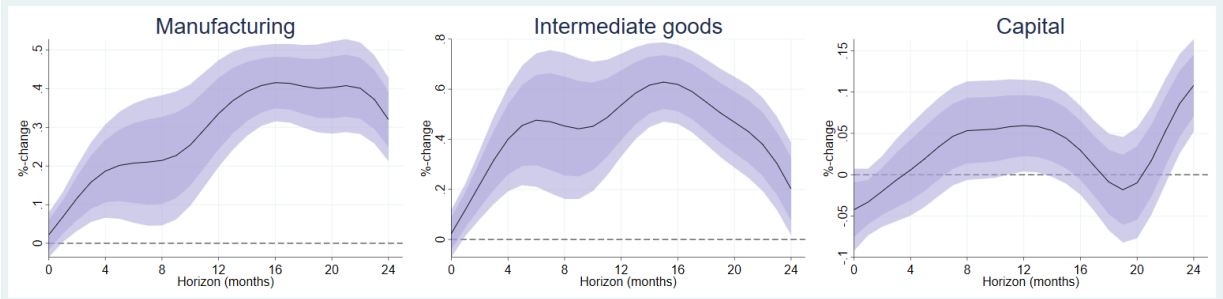


Figure 8: EA import price responses to one standard deviation positive Fed news shock of 3 bps. Vertical axis: %-change in the price index estimating $y_{t+h} - y_{t-1} = \alpha_h + \beta^{\epsilon}_h \epsilon_t + \mathbf{z}'_{t-j}\psi_h + \eta_{t+h}$ where $\boldsymbol{z} \equiv$ a vector of controls (6 lagged values of the dependent variable; linear, quadratic and cubic trends; monthly dummies for seasonal effects, and EA industrial confidence and EA real activity index of Scotti (2016) up to 6 months prior to shock). 68% and 90% confidence bands.

Figure 9 results are obtained running estimations again with controls for both oil price and the dollar value, and it confirms the interpretation that the importing industries experience the US expansion mainly through input costs and are thus rather price sensitive. Together with the documented price effects, it corroborates the higher costs of production as the likely explanation for the 'bad news' feature of the Fed information effects on the ultimate EA importers (right panel), with the persistent adverse Fed information effects driving these industries to either pay more for imports or to reduce the consumption of these factor inputs to the extent they are substitutable. Controlling for crude oil results in substantially milder adverse effects that largely fade away by the end of the three-year horizon, leaving much of the long-lasting international propagation of the shock observed in Figures 2 and 3 owing to the shock's effect on prices. When the US expands, the worldwide price and exchange rate fluctuations appear to the EA importers akin to a cost-push shock that increases businesses marginal costs.

The results also highlight the difference in the transmission channel of US business cycle to EA importers versus exporters; the ultimate exporters to the US (middle panel) are relatively unaffected by the inclusion of the oil-dollar channel. This suggests that the exporters are more directly affected by a change in demanded quantities when US business cycle turns, while the EA importers are more indirectly affected via international prices and exchange rates. Lastly, the value of USD and oil price tend to be inversely related in the period under study (2000s and 2010s), which motivates inclusion of dollar value when controlling for crude oil price – albeit the relatively tight correlation between the variables (which motivates their simultaneous inclusion in the reduced form model) will also result in less stable estimates, as visible from the more staggered impulse responses compared to earlier results.

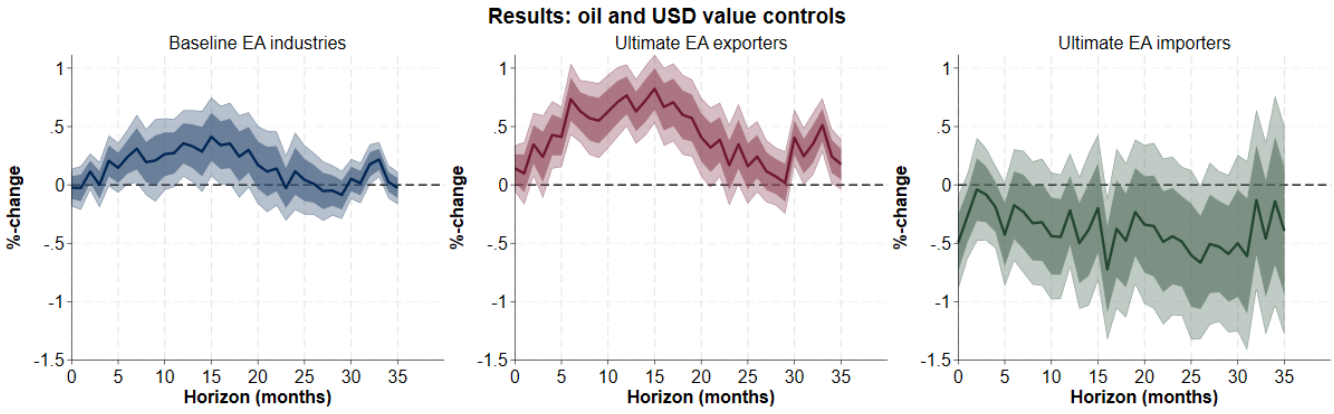


Figure 9: The overall response of EA IP-index to one standard deviation positive Fed news shock, controlling for broad dollar value and crude oil price. The overall effects comprise main effect and interaction terms, i.e. $\beta_h^c + \phi_h$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

3.3 The effects of other US macroeconomic variables

To address the question of which US macroeconomic forces the Fed news shocks could resemble, Figures 10 and 11 contrast the Fed information effects with the effects of other US macroeconomic variables on EA production. It does so applying the same local projections specification of Section 2.3, but now switching

the shock to monthly changes in US employment (Figure 10) or US consumer confidence series (Figure 11). This provides a comparison point to changes in US macroeconomic data without an equally evolved identification strategy as done in Jarocinski and Karadi (2020).[4] These results should be understood as a first pass at contrasting the Fed information effects with other US macroeconomic variables, noting that the new regressors are arguably not as well identified as the Fed news shock and could be already attenuated by anticipation among agents since their realisation is not necessarily "news" to the public. As for the Fed information shocks, reverse causality is addressed by controlling for EA macroeconomic variables.

Figures 10 and 11 show qualitatively similar responses in European production as we observe for the positive Fed information shocks; quantitatively the results are slightly muted from the Fed information effects. Figures 12 and 13 confirm that the ultimate EA exporters to the US benefit from the positive macroeconomic developments, while the ultimate EA importers from the US are harmed by it. The similarity in responses to the positive Fed news shocks and the positive changes in macroeconomic data suggest that the Fed information effects reflect benign US business cycle conditions with some combination of positive developments in US employment and consumer confidence. The fact that the Fed information effects resemble changes in US employment is not surprising given that the Fed is mandated to target full employment besides its inflation target, which speaks for a tendency of its economic outlook to involve substantial employment news content.

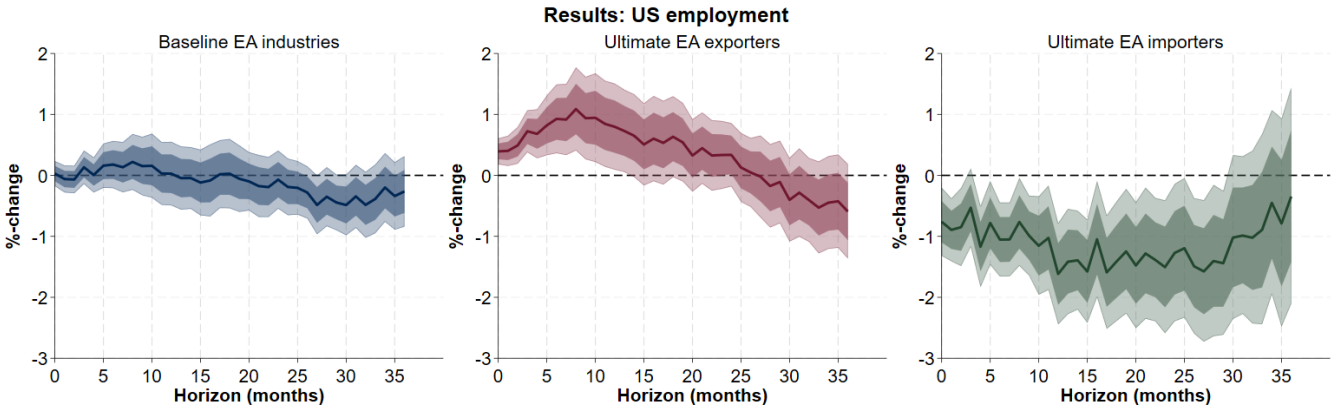


Figure 10: The overall response of EA IP-index to one standard deviation positive change in the US employment series. The overall effects comprise the main effect and interaction terms, i.e. $\beta_h^{\epsilon} + \phi_h$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands

[4]For both US employment and consumer confidence series, I take the first differences of the data to study the effects of the monthly change in the macrovariable in question. Moreover, the US employment series is constructed as the inverse of the US unemployment series in order to interpret it as a positive change in US business cycle.

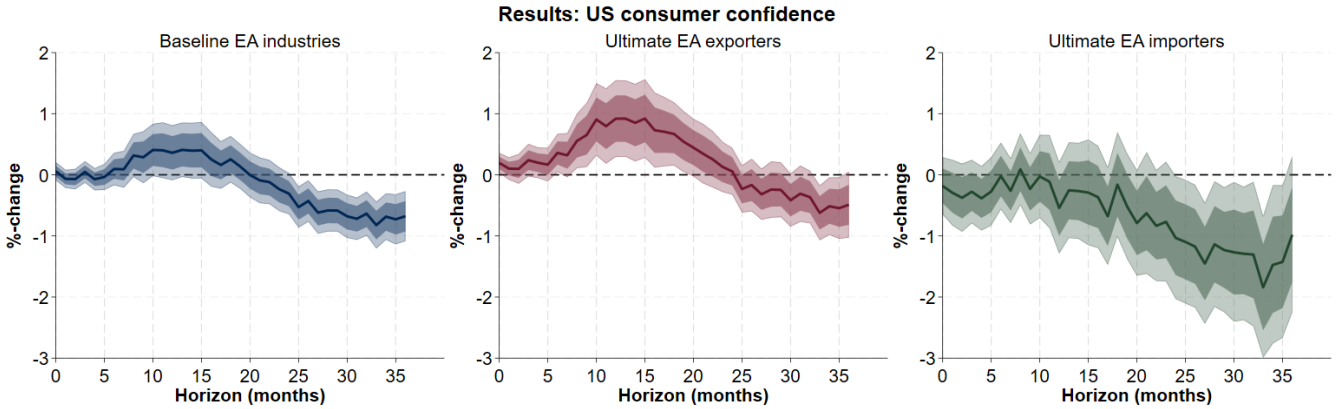


Figure 11: The overall response of EA IP-index to one standard deviation positive change in the US consumer confidence series. The overall effects comprise the main effect and interaction terms, i.e. $\beta_h^{\epsilon} + \phi_h$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

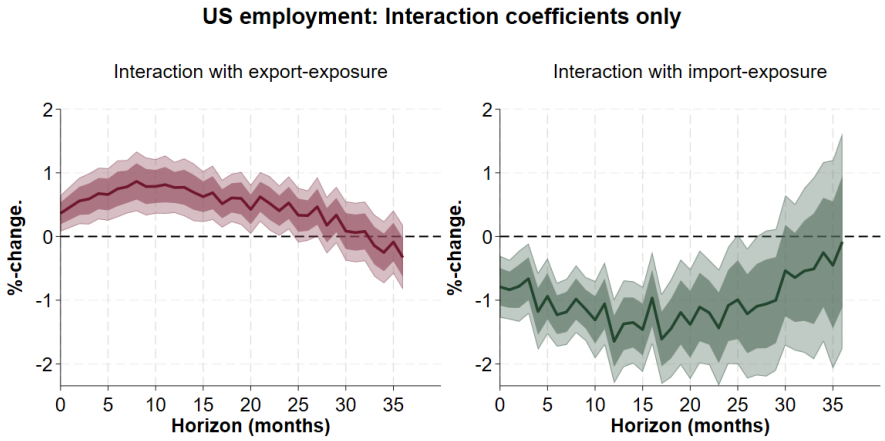


Figure 12: The interaction coefficients of the trade exposure variable with: the change in the US employment series. The interaction coefficient isϕ_h^i, $i \in \{fw, bw\}$ in the LP model of Section 2.3. 68% and 90% confidence bands.

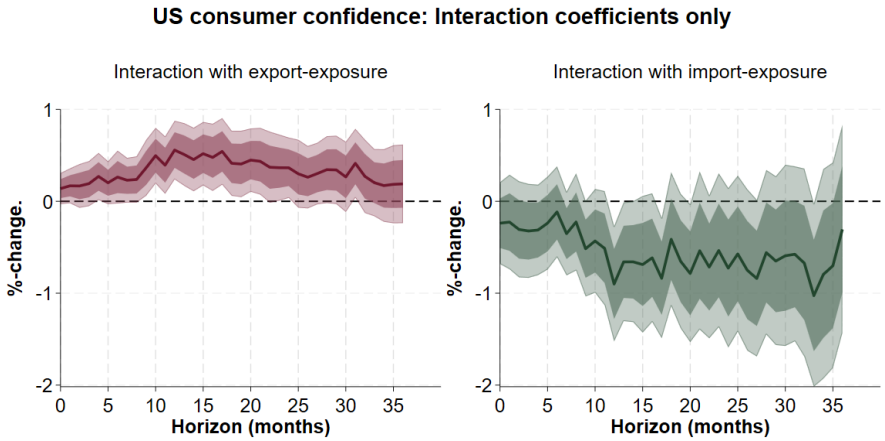


Figure 13: The interaction coefficients of the trade exposure variable with: the change in US consumer confidence series. The interaction coefficient isϕ_h^i, $i \in \{fw, bw\}$ in the LP model of Section 2.3. 68% and 90% confidence bands.

3.4 The Fed monetary shocks

This section turns lastly to the impact of the Fed monetary policy shocks on EA real activity, which in theory represent demand shocks of an opposite sign to the Fed information shocks. 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. The Fed monetary policy effects on Euro Area production are shown in Figures 1, 14 and 15, which are generated by applying the same local projection specification of Section 2.3, but replacing the Fed news shock this time with the exogenous Fed monetary shock series of Jarocinski and Karadi (2020). This gives us another key empirical result, besides the asymmetry in responses among European industries to the Fed news shocks: the Fed monetary effects mirror the Fed information effects on the aggregate (Figure 1), but very differently from the Fed information effects, the Fed monetary shocks interact little with the European industries' trade exposure to the US (Figure 15).

Observing the overall response of EA production to the Fed monetary shocks (Figure 14), we see that the baseline group (left panel) follows closely the aggregate pattern (Figure 1, right panel), with effects that are slightly stronger (statistically significant fall of 0.5% in the EA industrial production at trough) than the baseline Fed information effects. The exporting industries (middle panel) follow closely the aggregate pattern, rendering them nearly indistinguishable from the baseline group. This results from the lack of interaction of the monetary policy shock with trade links to the US economy, made apparent in Figure 15. The import-exposed industries (right panel) appear to receive, if anything greater estimate uncertainty from the interaction with the monetary shock on top of the adverse main effect, resulting in an overall effect close to zero. The noisy but offsetting effects could come from lower input prices induced by US monetary taming on the one hand, but dollar appreciation on the other hand, which is a rather robust finding in the data after the Fed tightens its monetary policy stance.

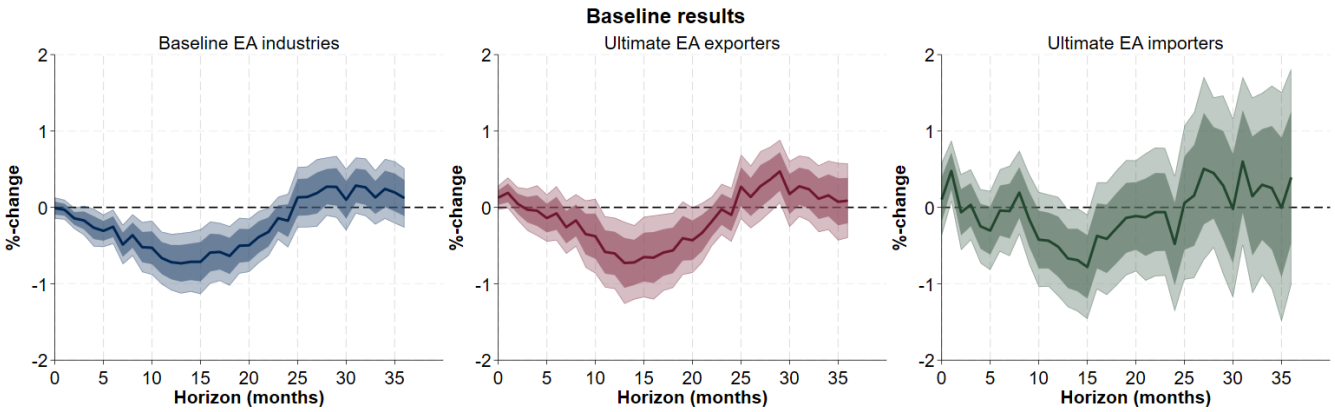


Figure 14: The overall response of EA IP-index to one standard deviation positive Fed monetary policy shock. The overall effects comprise the main effect and interaction terms, i.e. $\beta_h^{\epsilon} + \phi_h$ of a given variable in the LP model of Section 2.3. 68% and 90% confidence bands.

In sum, the lack of interaction generates broadly adverse Fed monetary effects across the board, with only the most US-imports-linked EA industries having no clear response to the Fed monetary shock. As

such, the homogeneous responses to the Fed monetary policy stand in contrast with the Fed information effects and indicate that channels of transmission for the two shocks likely differ. The homogeneous effects hinge on monetary effects that come through prices affecting the manufacturing EA industries more uniformly. While these broad baseline effects are also present for the Fed information effects, they are clearly dominated by the distinct effects that the Fed news shock has through trade links (Figures 2 and 3). Indeed, robustness tests show that the adverse Fed monetary effects displayed above are sensitive to the inclusion of exchange rates and commodity prices in the model; adverse Fed monetary effects, if any, only occur after about 1.5 years of the Fed monetary shock's occurrence when these absolute and relative price movements are controlled for.

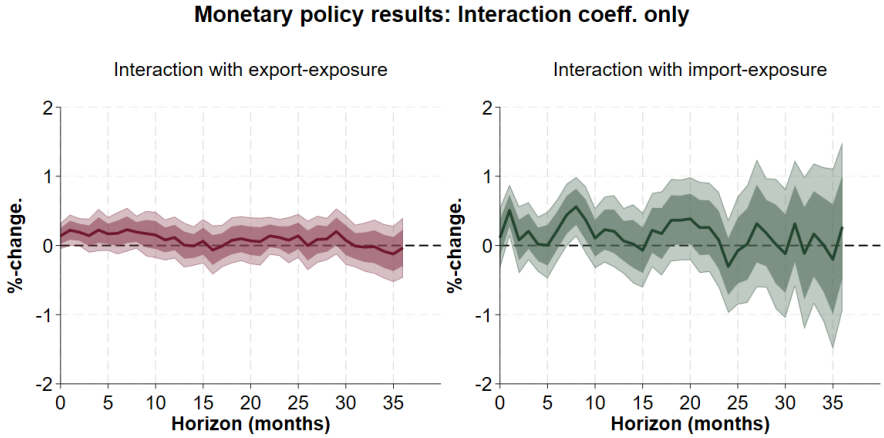


Figure 15: Interaction coefficients of the forward participation dummy (left) and backward participation dummy (right) with the Fed monetary policy shock, which is ϕ_h in the LP model of Section 2.3. The response of IP-index is scaled to one standard deviation positive Fed monetary policy shock. 68% 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 are 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 proxy 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. Naturally 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.[5] 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 Fed monetary effects analysis of Section 3.4, the supply-side Fed information shocks misclassified as pure monetary policy shocks could create an attenuation bias in the results if they add to foreign demand in the US, since a monetary shock has the opposite sign and the sample of monetary policy shocks would become contaminated with misclassified information shocks counteracting the estimated impact of Fed monetary policy on the EA activity.[6] 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 (2023) 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 surprise element during the FOMC announcements should then lie in the information asymmetry between the public and the central bank about the monetary policy function. The findings of

[5] The positive supply shock in the US could manifest itself as a positive demand shock for the EA as long as US economic growth increases demand for foreign goods; e.g. as the sectors that become more productive grow in size or the wealth effect of the productivity gain spills over more widely in the US economy adding to demand.

[6] 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 in the face of the positive US supply shock.

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.

In fact, the capacity of the central bank as managing agents' beliefs about the economy need not hinge on superiority of information per se; after all, the public and the central bank arguably have somewhat equal forecasting capabilities, and key statistics to the US monetary policy decision, the CPI and unemployment data, are compiled by the Bureau of Labor Statistics, a separate government body, who makes new macro data available to all agents simultaneously, including the central bank. Yet, these data are made public with a lag of their collection and are used to predict the economy months and years ahead, which naturally involves estimates with widening confidence bands. Given the uncertainty around economic estimates, agents who each have their private view of the economy but do not have full oversight into *other agents*' estimates, may benefit from a validation of their private information. The central bank, as a credible agent, can perform this 'blessing role' arguably better than many other players in the economy and thus use it as a policy tool of coordinating the public's beliefs (Morris and Shin (2002)). If this theory is to hold, what is observed as asset price movements during the FOMC announcements would be *private information becoming common knowledge* (Aumann (1976)). The need for coordinated beliefs, which allows agents to take action, gets emphasised in settings such as equity markets where valuation and payoffs require other market participants' action, set in motion by beliefs.

This discussion is to say that the empirical evidence brought forth, which support the assumption that the Fed news shocks identified from stock market reactions can be taken as a proxy for the underlying state of the US economy, may hold under different types of information frictions among the Fed and the public, with the EA response not allowing to distinguish where the information asymmetry lies between the Fed and the financial markets.

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 strong 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 Open-economy model

5.1 Environment

The previous section brought reduced form evidence on the patterns of US demand shock transmission to the Euro Area. This section presents a theoretical framework for viewing those patterns, which the model is able to qualitatively replicate. For the purpose of rationalising those patterns through a theoretical lens, the model is kept simplified to the extent possible in the number of agents in the economies, while still being able to take an explicit stance on the transmission mechanism into the EA economy and enabling intertemporal dynamics between the economy's agents, hence a dynamic general equilibrium approach. The model is a two-country model featuring incomplete asset markets and nominal rigidities. It comes closest to Benigno (2009) with a number of substantial differences, most notably in that it structures the firm side of both economies to generate a two-speed EA economy when the US economy expands and it limits the modelling of the monetary policy to US only with a simplified money supply rule for the recipient economy of the shock, the Euro Area.

The model's world economy consists of the Euro Area and the US. The EA block features a representative household that supplies labour to the import and export sectors of the EA economy and consumes the output of the EA importer firm. The EA export sector consists of an exporter firm, who uses only domestic labour in its production technology to make an intermediate good sold downstream to a US tradable firm. The EA import sector consists of an importer firm whose technology uses domestic labour and intermediate inputs imported from the US tradable firm. A competitive composite good aggregator compiles the EA importer's output in order to make a final good being sold for the consumption of the EA household; i.e. all output of EA importer flow to the EA household via the pass-through entity.

The US block features a representative household, a tradable firm (a single open economy sector in the US), a final good aggregator entity and the central bank. The US household is tightly linked to the US tradable firm; she supplies labour to the US tradable firm and consumes part of its output. The US tradable firm is linked to (i) the EA exporter via imports of intermediate goods from it, and (ii) to the EA importer via exports of its output to it. The intermediate good that the US firm produces is thus being sold internationally to the EA importer and domestically to the US household, passing through a Dixit-Stiglitz aggregator that is simply a pass-through entity that transforms the US tradable firm's output into a composite good.

Market power and nominal rigidities are at the level of the downstream firms in the two economies -— the EA importer and the US tradable producer; both face monopolistic competition and Calvo price stickiness (Calvo, 1983). The EA exporter faces perfect competition being an upstream supplier in the world markets with no price rigidities. All international trade is conducted in the producer's currency. The US central bank governs the return of the only internationally tradable asset in the economy, a non-state contingent risk-free bond denominated in US dollars. To render the world economy with a single interest paying as-

set, the EA economy features money through money-in-utility in the EA household's utility function and a simple money supply rule for the EA central bank. Stationarity is induced via a debt–elastic interest–rate premium in the bond return and a quadratic portfolio adjustment costs in the US household's problem, à Schmitt-Grohé and Uribe (2003b).

Section 5.6 displays the model's impulse response functions to the two types of US demand shocks that are a model short-hand for the empirical shocks studied in earlier sections; the Fed news shock is modelled to originate at the level of the US household who receives a shock to her patience to postpone consumption (discount factor shock), and the Fed monetary policy shock is modelled as a shock to the US Taylor rule. The purpose is to demonstrate transmission paths of the shocks to the EA economy that match qualitatively the reduced form patterns of Section 3. Alternative shock specifications could be admissible. The section below summarises the model, with market clearing conditions in Section C.1. The model is solved by linearisation and first-order perturbation around the steady state equilibrium.

5.2 The United States Economy

5.2.1 US household

US household solves:

$$\max_{\{C_t^*, n_t^*, B_t^{US}\}_{t\geq 0}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Delta_t \left[\frac{(C_t^*)^{1-\sigma_U}}{1-\sigma_U} - \frac{\chi_U}{1+\varphi_U} (n_t^*)^{1+\varphi_U} - \frac{\phi_b}{2} \left(B_t^{US} - \bar{B}\right)^2 (C_t^*)^{\sigma_U} \right], \tag{4}$$

subject to:

$$P_t^{US} C_t^* + B_t^{US} \leq W_t^* n_t^* + \frac{i_{t-1}^{US}}{\pi_t^U} \left(1 + \text{prem}_{t-1}\right) B_{t-1}^{US}, \tag{5}$$

$$\lim_{T\to\infty} \mathbb{E}_t \left[\Lambda_T^{US} B_T^{US} \right] = 0. \tag{6}$$

where $0 < \beta_U < 1$ is the US discount factor, d_t^U is a shock to US household impatience, $\Delta_t \equiv \prod_{s=0}^{t-1} \beta_U e^{-d_s^U}$ is the US discount factor subject to impatience shocks series up to time t, C_t^* is US consumption (CRRA with coefficient $\sigma_U > 0$), n_t^* is labour supply (disutility parameters $\chi_U > 0, \varphi_U > 0$), P_t^{US} is the US CPI, W_t^* is the nominal wage, B_t^{US} is the risk-free USD bond position, i_t^{US} is the US nominal interest rate, $\pi_t^U \equiv P_t^{US}/P_{t-1}^{US}$ is gross inflation, prem_t is the debt premium, $\bar{B}$ is the steady-state bond level used in the adjustment cost, and $\Lambda_t^{US} \equiv \beta_U e^{-d_t^U} \left(\frac{C_{t+1}^*}{C_t^*}\right)^{-\sigma_U}$ is the one-period US stochastic discount factor.

First order conditions:

$$\text{(i) Labor supply:} \quad W_t^* = \chi_U P_t^{US} (n_t^*)^{\varphi_U} (C_t^*)^{\sigma_U}, \tag{7}$$

$$\text{(ii) US Euler:} \quad 1 = \beta_U e^{-d_t^U} \mathbb{E}_t \left[\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-\sigma_U} \frac{i_t^{US}}{\pi_{t+1}^U} (1 + \text{prem}_t) \right] - \phi_b \left(B_t^{US} - \bar{B}\right) (C_t^*)^{\sigma_U}. \tag{8}$$

We obtain the ex-ante real interest rate by the Fisher condition from household SDF and risk-free bond pricing conditions:

$$r_t \approx i_t^{US} - \mathbb{E}_t[\pi_{t+1}^*]. \tag{9}$$

US composite-good aggregator: A competitive Dixit–Stiglitz aggregator combines differentiated varieties $y_t^*(j)$ into the final composite Y_t^*, delivering the US price index and the variety demand:

$$P_t^{US} = \left(\int_0^1 P_t^{US}(j)^{1-\varepsilon_U}\, dj\right)^{\frac{1}{1-\varepsilon_U}}. \tag{10}$$

$$y_t^*(j) = \left(\frac{P_t^{US}(j)}{P_t^{US}}\right)^{-\varepsilon_U} Y_t^*, \tag{11}$$

with $Y_t^* = C_t^* + m_t$ from market clearing.

5.2.2 US tradable firm

A continuum of monopolistically competitive tradable firms produce varieties $j \in [0,1]$ by solving:

(i) **A cost minimisation problem:**

$$\min_{n_t^*(j),\, x_t^*(j)} W_t^*\, n_t^*(j) + p_{x,t}^{USD}\, x_t^*(j) \quad \text{s.t.} \quad y_t^*(j) = A_t^*\, n_t^*(j)^{1-\phi_U}\, x_t^*(j)^{\phi_U}. \tag{12}$$

$$\text{with } p_{x,t}^{USD} = p_{x,t}^{EUR}/S_t.$$

Cost minimisation implies the conditions:

$$\text{(i) Optimal input mix (cost share):} \quad \frac{W_t^*}{p_{x,t}^{US}} = \frac{1-\phi_U}{\phi_U}\frac{x_t^*(j)}{n_t^*(j)}, \tag{13}$$

$$\text{(ii) Unit cost:} \quad \mathrm{uc}_t^* \equiv \frac{K_\phi}{A_t^*}(W_t^*)^{1-\phi_U}\left(p_{x,t}^{US}\right)^{\phi_U}, \qquad K_\phi \equiv \frac{1}{(1-\phi_U)^{1-\phi_U}\phi_U^{\phi_U}}, \tag{14}$$

$$\text{(iii) Real marginal cost:} \quad \mathrm{MC}_t^* \equiv \frac{\mathrm{uc}_t^*}{P_t^{US}}. \tag{15}$$

(ii) **A price-setting problem:**

In each period, a fraction $1-\theta_U$ of tradable firms can reset price; non-resetting firms index by $\xi_{\pi U}$ to last period's inflation. With desired (gross) markup $\mu = \varepsilon_U/(\varepsilon_U - 1)$ and a shifter $\widehat{\mu}_t^*$, we obtain the US New Keynesian Phillips curve and and price-level law:

$$\log\pi_t^* - \log\bar{\Pi} = \beta_U\left(\log\pi_{t+1}^* - \log\bar{\Pi}\right) + \xi_{\pi U}\left(\log\pi_{t-1}^* - \log\bar{\Pi}\right) + \kappa_U \log\left(\mu\,\mathrm{MC}_t^*\right) + \kappa_U \log\widehat{\mu}_t^*, \tag{16}$$

$$P_t^{US} = \frac{\pi_t^*}{\bar{\Pi}}\, P_{t-1}^{US}, \qquad \kappa_U \equiv \frac{(1-\theta_U)(1-\beta_U\theta_U)}{\theta_U}. \tag{17}$$

where $y_t^*(j)$ is variety-j output and Y_t^* aggregate US output; $P_t^{US}(j)$ is the price of variety j and P_t^{US} the US price index; $\pi_t^* \equiv P_t^{US}/P_{t-1}^{US}$ is gross US inflation; $n_t^*(j)$ is US labor hired, $x_t^*(j)$ the imported input, with factor prices W_t^* (US nominal wage) and $p_{x,t}^{US}$ (USD price of the imported input); A_t^* is US TFP; $\phi_U \in (0,1)$ is the imported-input share; $\varepsilon_U > 1$ is the demand elasticity; $\mu = \varepsilon_U/(\varepsilon_U - 1)$ is the desired (gross) markup and $\widehat{\mu}_t^*$ its shifter; $\theta_U \in (0,1)$ is Calvo stickiness and $\xi_{\pi U} \in [0,1)$ the indexation parameter; $\beta_U \in (0,1)$ is the discount factor and $Q_{t,t+k}^*$ the US stochastic discount factor from t to $t+k$; uc_t^* is unit cost (USD) and $\mathrm{MC}_t^* \equiv \mathrm{uc}_t^*/P_t^{US}$ real marginal cost; $K_\phi \equiv \left[(1-\phi_U)^{1-\phi_U}\phi_U^{\phi_U}\right]^{-1}$ is the Cobb–Douglas constant; $Y_{t+k|t}^*$ is demand faced in $t+k$ by a firm that reset in t; $\bar{\Pi}$ is the gross inflation target; and $\kappa_U \equiv (1-\theta_U)(1-\beta_U\theta_U)/\theta_U$.

5.2.3 US central bank:

The central bank sets monetary policy according to the Taylor rule:

$$\log i_t^{US} \;=\; \rho_i \log i_{t-1}^{US} \;+\; (1-\rho_i)\Big[\log \bar{i} + \phi_\pi \log\Big(\tfrac{\pi_t^*}{\bar{\Pi}}\Big) + \phi_x\, g_t\Big] \;+\; i_t^W, \qquad \bar{i} = \bar{\Pi}/\beta_U. \tag{18}$$

where g_t is the US output gap, defined as $g_t \equiv \log Y_t^* - \log Y_t^{*,n}$, with Y_t^* denoting actual US output and $Y_t^{*,n}$ the flexible-price (natural) level of US output.

5.3 The Euro Area Economy

5.3.1 EA household

EA household solves:

$$\max_{\{C_t, n_t, M_t^E, B_t^{EA}\}_{t\geq 0}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_E^t \left[\frac{C_t^{1-\sigma_E}}{1-\sigma_E} - \frac{\chi_E}{1+\varphi_E}\, n_t^{1+\varphi_E} + \phi_c \log\Big(\tfrac{M_t^E}{P_t^E}\Big)\right], \tag{19}$$

subject to

$$P_t^E C_t + M_t^E + S_t B_t^{EA} \;\leq\; W_t^E n_t + M_{t-1}^E + \frac{S_t}{\pi_t^U}\, i_{t-1}^{US}\big(1+\mathrm{prem}_{t-1}\big)\, B_{t-1}^{EA}, \tag{20}$$

$$\lim_{T\to\infty} \mathbb{E}_t\big[\Lambda_T^{EA}\, q_T\, B_T^{EA}\big] = 0. \tag{21}$$

Where $0 < \beta_E < 1$ is the discount factor, C_t is consumption (CRRA with coefficient $\sigma_E > 0$), n_t is labor supply (disutility parameters $\chi_E > 0, \varphi_E > 0$), M_t^E is nominal money, P_t^E is the EA CPI, W_t^E is the nominal wage, S_t is the nominal exchange rate (EUR per a unit of USD), B_t^{EA} is the position in the USD risk-free bond, i_t^{US} is the US gross nominal rate, π_t^U is US gross inflation, prem_t is the debt premium, $q_t \equiv S_t P_t^U/P_t^E$ is the real exchange rate, and $\Lambda_t^{EA} \equiv \beta_E\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma_E}$ is the EA stochastic discount factor.

First order conditions:

$$\text{(i) Labor supply:} \quad W_t^E = \chi_E P_t^E \, n_t^{\varphi_E} C_t^{\sigma_E}, \tag{22}$$

$$\text{(ii) EA Euler:} \quad 1 = \beta_E \mathbb{E}_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma_E} \frac{i_t^{US}}{\pi_{t+1}^U} (1 + \text{prem}_t) \frac{q_{t+1}}{q_t} \right], \tag{23}$$

$$\text{(iii) Money demand:} \quad \phi_c \frac{P_t^E}{M_t^E} = \left[\frac{i_t^{US}}{\pi_{t+1}^U} (1 + \text{prem}_t) \frac{q_{t+1}}{q_t} - 1 \right] C_t^{-\sigma_E}. \tag{24}$$

EA composite-good aggregator: A competitive Dixit–Stiglitz aggregator combines differentiated import varieties $c_t(j)$ into the aggregate consumption composite C_t, delivering the EA price index and, using market clearing $y_t(j) = c_t(j)$, the variety demand:

$$P_t^{EA} = \left(\int_0^1 P_t^{EA}(j)^{1-\varepsilon_E} \, dj \right)^{\frac{1}{1-\varepsilon_E}}. \tag{25}$$

$$y_t(j) = \left(\frac{P_t^{EA}(j)}{P_t^{EA}} \right)^{-\varepsilon_E} C_t. \tag{26}$$

5.3.2 EA Importer firm

A continuum of monopolistically competitive EA importers produce/assemble varieties $j \in [0,1]$ by solving:

(i) **A cost minimisation problem:**

$$\min_{n_t(j),\, m_t(j)} \; W_t \, n_t(j) + p_{m,t}^{\text{EUR}} \, m_t(j) \tag{27}$$

$$\text{s.t.} \quad y_t(j) = A_E \left(\eta_E \, m_t(j)^{\frac{\sigma_M - 1}{\sigma_M}} + (1 - \eta_E) \, n_t(j)^{\frac{\sigma_M - 1}{\sigma_M}} \right)^{\frac{\sigma_M}{\sigma_M - 1}}. \tag{28}$$

Cost minimisation implies the conditions:

$$\text{(i) Armington import demand:} \quad m_t = \eta_E \left(\frac{P_t^{EA}}{p_{m,t}^{\text{EUR}}} \right)^{\sigma_M} C_t, \tag{29}$$

$$\text{(ii) Unit cost:} \quad \text{uc}_t = \frac{1}{A_E} \left(\eta_E \, (p_{m,t}^{\text{EUR}})^{1-\sigma_M} + (1 - \eta_E) \, W_t^{1-\sigma_M} \right)^{\frac{1}{1-\sigma_M}}, \tag{30}$$

$$\text{(iii) Real marginal cost:} \quad \text{MC}_t \equiv \frac{\text{uc}_t}{P_t^{EA}}. \tag{31}$$

(ii) A price-setting problem:

In each period, a fraction $1 - \theta_E$ of EA importers can reset price; non-resetting firms index by $\xi_{\pi E}$ to last period's inflation. With desired (gross) markup $\mu_E = \varepsilon_E / (\varepsilon_E - 1)$, we obtain the EA New Keynesian Phillips

curve and the price-level law:

$$\log \pi_t - \log \bar{\Pi} = \beta_E \big(\log \pi_{t+1} - \log \bar{\Pi}\big) + \xi_{\pi E} \big(\log \pi_{t-1} - \log \bar{\Pi}\big) + \kappa_E \log\big(\mu_E \, \mathrm{MC}_t^E\big), \tag{32}$$

$$P_t^{EA} = \frac{\pi_t}{\bar{\Pi}} P_{t-1}^{EA}, \qquad \kappa_E \equiv \frac{(1-\theta_E)(1-\beta_E \theta_E)}{\theta_E}. \tag{33}$$

where $\pi_t \equiv P_t^{EA} / P_{t-1}^{EA}$ is EA gross inflation; P_t^{EA} is the EA price index; $p_{m,t}^{\mathrm{EUR}} \equiv S_t \, P_t^{US}$ is the EUR price of the US tradable (US price converted to euros); $\beta_E \in (0,1)$ is the EA discount factor; $\theta_E \in (0,1)$ is Calvo stickiness; $\xi_{\pi E} \in [0,1)$ is the indexation parameter; $\varepsilon_E > 1$ is the demand elasticity; $\mu_E = \varepsilon_E / (\varepsilon_E - 1)$ is the desired markup; $\mathrm{MC}_t^E \equiv \mathrm{uc}_t / P_t^{EA}$ is the EA importer's real marginal cost (with uc_t the unit cost from the cost-minimisation block); and $\bar{\Pi}$ is the gross inflation target.

5.3.3 EA exporter firm

EA exporter solves:

$$\max_{n_{X,t} \geq 0} \; p_{x,t}^{EUR} \, x_t \; - \; W_t \, n_{X,t} \quad \text{s.t.} \quad x_t \; = \; A_X \, n_{X,t}^{1-\mu_E}, \tag{34}$$

First order condition: $W_t \, n_{X,t} \; = \; (1-\mu_E) \, p_{x,t}^{EA} \, x_t$, where x_t is the exporter's output (intermediate good sold to the US tradable firm), $n_{X,t}$ is EA labor hired by the exporter, W_t is the EA nominal wage, $p_{x,t}^{EUR}$ is the EUR price received by the exporter, S_t is the nominal exchange rate (EUR per USD), $A_X > 0$ is exporter productivity, and $\mu_E \in (0,1)$ governs decreasing returns.

5.3.4 EA central bank

The EA central bank supplies money according to a money–growth policy rule:

$$\mu_{M,t} \; = \; \rho_M \, \mu_{M,t-1} \; + \; (1-\rho_M) \, \mu_M \; - \; \phi_M \big(\log \pi_t - \log \bar{\Pi}\big) \; + \; \sigma_M^E \, \varepsilon_{M,t}^E. \tag{35}$$

with the law of motion:

$$\log M_t \; = \; \log M_{t-1} \; + \; \mu_{M,t}, \tag{36}$$

where M_t is the EA nominal money stock; $\mu_{M,t}$ is money growth; $\rho_M \in [0,1)$ is inertia; μ_M is the steady-state money–growth target; $\phi_M > 0$ controls feedback to inflation deviations; $\sigma_M^E > 0$ scales the monetary shock $\varepsilon_{M,t}^E$; $\pi_t \equiv P_t^{EA} / P_{t-1}^{EA}$ is EA gross inflation; and $\bar{\Pi}$ is the gross inflation target.

5.4 Exogenous Processes

$$\begin{aligned} \log A_t &= (1-\rho_A) \log \bar{A} + \rho_A \log A_{t-1} + \sigma_A \varepsilon_t^A, & d_t^U &= \rho_d \, d_{t-1}^U + \sigma_d \varepsilon_t^d, \\ \log \hat{\mu}_t &= \rho_\mu \log \hat{\mu}_{t-1} + \sigma_\mu \varepsilon_t^\mu, & i_t^W &= \rho_{iW} \, i_{t-1}^W + \sigma_{iW} \varepsilon_t^i. \end{aligned} \tag{37}$$

with i.i.d. shocks $\varepsilon_t^A, \varepsilon_t^d, \varepsilon_t^\mu, \varepsilon_t^i, \varepsilon_{M,t}^E \overset{\text{i.i.d.}}{\sim} \mathcal{N}(0,1)$.

5.5 Calibration

The model is calibrated externally to the parameters and sources listed in Table 1.

Category	Symbol (code)	Value	Note/Target	Reference
Preferences	σ_U (sigmaU)	1.50	CRRA $\Rightarrow$ IES ≈ 0.67	Smets & Wouters (2007, AER)
	σ_E (sigmaE)	1.50	Symmetric to US	Smets & Wouters (2007)
	φ_U (varphiU)	2.00	Inverse Frisch	Smets & Wouters (2007)
	φ_E (varphiE)	2.00	Inverse Frisch	Smets & Wouters (2007)
US pricing & tech	ϵ_Y (epsY)	10.0	Markup $\mu = \frac{\epsilon}{\epsilon-1} \approx 1.11$	Woodford (2003)
	θ_U (thetaU)	0.75	Price duration ~4 qtrs	Smets & Wouters (2007)
	ξ_π (xi_pi)	0.10	Low price indexation	Cogley & Sbordone (2008, AER)
	ϕ_U (phiU)	0.28	Materials/imported-input share	US BEA IO Tables
EA importer	ϵ_C (epsC)	10.0	Markup $\mu_C \approx 1.11$	Woodford (2003)
(pricing/tech)	θ_E (thetaE)	0.80	Import price duration	Gopinath & Rigobon (2008, QJE)
	$\xi_{\pi,E}$ (xi_piE)	0.20	Lower indexation	Gopinath & Rigobon (2008, QJE)
	η_E (etaE)	0.10	Import share in C	Corsetti–Dedola–Leduc (2008, JME)
	σ_M (sigmaM)	1.10	Armington elasticity ≈ 1	Broda & Weinstein (2006, QJE)
	s^{CES} (sCES)	1	CES aggregator	Hooper–Johnson–Marquez (2000)
EA exporter	μ_E (muE)	0.20	Mild decreasing returns	Basu–Fernald (1997) style
	A_X (AX)	8.0	Scale/normalization	— (normalization)
Policy (US)	ρ_i (rho_i)	0.80	Interest smoothing	Smets & Wouters (2007)
	ϕ_π (phi_pi)	1.50	Taylor principle	Taylor (1993)
	ϕ_x (phi_x)	0.25	Output-gap weight	Smets & Wouters (2007)
	Π (Pi_bar)	1.005	2% annual inflation target	Taylor (1993)
External	ψ_b (psib)	0.005	Debt-elastic UIP premium	Schmitt-Grohé & Uribe (2003, JIE)
	ϕ_b (phib)	0.002	Bond adj. cost	Schmitt-Grohé & Uribe (2003)
	$\bar{b}$ (bbar)	-0.30	NFA/Y ratio	Lane & Milesi-Ferretti (2007)
MIU (EA)	ϕ_c (phi_c)	1.00	Scale in money demand	— (normalization)
	ϕ_R (phi_R)	1.20	Semi-elasticity to rate	Ireland (2009, JMCB)
	ρ_M (rho_M)	0.30	Money-growth inertia	Taylor-type rule
	ϕ_M (phi_M)	1.50	Feedback on π_E	Taylor-type rule
TFP (US)	ρ_A (rhoA)	0.90	Persistence	Backus–Kehoe–Kydland (1994)
	σ_A (sigA)	0.007	Std. dev.	Standard small-open RBC
Shocks	ρ_d (rhod)	0.60	Pref. shock persistence	Smets & Wouters (2007)
	σ_d (sigd)	0.010	eD0 size (visible IRFs)	Standard calibration
	σ_{iW} (sigiW)	0.005	$\approx$ 50 bps MP shock	Christiano–Eichenbaum–Evans (2005, JPE)

Table 1: Calibration used in the two country model. The papers in the table refer to: Smets and Wouters (2007);Woodford (2003); Cogley and Sbordone (2008); U.S. Bureau of Economic Analysis; Gopinath and Rigobon (2008); Corsetti et al. (2008); Broda and Weinstein (2006); Hooper et al. (2000); Basu and Fernald (1997); Taylor (1993); Schmitt-Grohé and Uribe (2003a); Lane and Milesi-Ferretti (2007); Ireland (2009); Backus et al. (1994); Christiano et al. (2005)

5.6 Model prescribed patterns

The baseline empirical results showed us that following the positive Fed news shock, the dollar is expected to appreciate, the US trade deficit widens, the EA exporter expands and the EA importer contracts. In turn, following a Fed monetary tightening shock, the EA exporter contracts, the EA importer is hardly affected. This section confronts those empirical patterns with the model's predictions.

5.6.1 The expected exchange rate movement

With a single risk-free USD-denominated nominal bond traded internationally, the households' Euler conditions give a consumption-based uncovered interest parity (UIP) condition, which in logarithmic terms is:

$$\mathbb{E}_t \Delta s_{t+1} = \mathbb{E}_t\left(\pi^{US}_{t+1} - \pi^{EA}_{t+1}\right) + \sigma_U \mathbb{E}_t \Delta c^{US}_{t+1} - \sigma_E \mathbb{E}_t \Delta c^{EA}_{t+1} + \Gamma_t \tag{38}$$

where Δs_{t+1} is the change in the nominal exchange rate (EUR per USD), π^i are inflation rates, Δc^i are consumption growth rates, σ_i are risk-aversion coefficients in the household's utility function, and Γ_t collects risk premia/Jensen terms, which will drop out by certainty equivalence under a first-order perturbation. Note that in the economy of a single traded asset, the US-EA interest rate differential does not appear in the UIP because a rise in the bond's interest rates incentivises savings for both households alike.

US impatience (discount-factor) shock: A fall in the US discount factor raises expected US inflation and current US demand. In the UIP (38),

$$\mathbb{E}_t \Delta s_{t+1} = \underbrace{\mathbb{E}_t\left(\pi^{US}_{t+1} - \pi^{EA}_{t+1}\right)}_{>0} + \underbrace{\sigma_U \mathbb{E}_t \Delta c^{US}_{t+1}}_{<0} - \underbrace{\sigma_E \mathbb{E}_t \Delta c^{EA}_{t+1}}_{<0}, \tag{39}$$

where US consumption jumps on impact and is expected to fall (mean-revert), while EA consumption is expected to recover; hence the two consumption-growth terms are negative and *dampen* appreciation. The positive expected US-EA inflation differential dominates so that $\mathbb{E}_t \Delta s_{t+1} > 0$. From households' incentive point of view, the willingness of the EA household to lend to the US household is rationalised by an expected dollar appreciation (higher future bond returns in euros) which compensates for the loss in real return from higher expected US inflation. The consumption-insurance terms mitigate the demanded appreciation because the bond transfers *more* resources to a future state of *high* expected EA consumption (serving as a poor consumption hedge). The stylised model of few real frictions does not exhibit the kind of inertia in the consumption responses to the shock that would generate a hump-shaped consumption response, which would lead the consumption differential to also contribute to an expected dollar appreciation.

In terms of timing, we see in Figure 16 that the consumption-growth differential of (38) is most negative on impact: US consumption jumps up (so its expected growth is negative) while EA consumption is expected to rebound (so its expected growth is positive). This exerts a short-lived *depreciation* pressure on the dollar. By contrast, the expected inflation differential is positive and adjusts more slowly because of inertia in monetary policy response and price stickiness. With the consumption wedge dissipating quickly while the inflation differential persists, the right-hand side of (38) turns and remains positive, delivering expected dollar appreciation. The spot exchange rate therefore follows a hump-shaped path: a brief dampening from the consumption differential terms, followed by appreciation as the inflation term fully takes over.

US monetary policy shock: A contractionary shock (37) to the Taylor rule (18) raises the policy rate and the ex-ante real rate, $r_t \approx i_t^{US} - \mathbb{E}_t[\pi_{t+1}^*]$, producing an *on-impact* USD appreciation. In the UIP (38),

$$\mathbb{E}_t \Delta s_{t+1} = \underbrace{\mathbb{E}_t\left(\pi_{t+1}^{US} - \pi_{t+1}^{EA}\right)}_{<0} + \underbrace{\sigma_U \mathbb{E}_t \Delta c_{t+1}^{US}}_{\gtrsim 0} - \underbrace{\sigma_E \mathbb{E}_t \Delta c_{t+1}^{EA}}_{\gtrsim 0}, \tag{40}$$

the inflation differential turns negative – US disinflation is faster than in the EA –, while the consumption differential is small because both blocs' consumption are expected to mean-revert upward, so the two growth terms largely offset. Hence $\mathbb{E}_t \Delta s_{t+1} < 0$ after the shock; the spot exchange rate jumps up on impact and then depreciates monotonically back toward baseline without a hump, unlike for the discount-factor shock.

5.6.2 US trade balance

Define the value of US exports to the EA of the US tradable sold abroad as $X_t^{US} \equiv P_t^{US} m_t$, and the value of US imports from the EA as $M_t^{US} = p_{x,t}^{USD} x_t^*$. Define also the export share of sales $s_{X,t} \equiv X_t^{US}/(P_t^{US} Y_t^*) = m_t / Y_t^*$. From cost minimization (12)–(14) and monopolistic pricing (16), total US sales satisfy $P_t^{US} Y_t^* = \mu_t \, \mathrm{uc}_t^* \, Y_t^*$. The imported–input spending share in sales equals the cost share divided by the markup, hence:

$$\frac{M_t^{US}}{P_t^{US} Y_t^*} = \frac{p_{x,t}^{USD} x_t^*}{P_t^{US} Y_t^*} = \frac{\phi_U}{\mu_t}.$$

Then the trade balance (in USD values) can be written as:

$$TB_t^{US} \equiv X_t^{US} - M_t^{US} = P_t^{US} Y_t^* \left(s_{X,t} - \frac{\phi_U}{\mu_t}\right). \tag{41}$$

Totally differentiating gives:

$$dTB_t^{US} = \underbrace{P_t^{US} Y_t^* \, ds_{X,t}}_{\text{composition}} + \underbrace{\left(s_{X,t} - \tfrac{\phi_U}{\mu_t}\right) d\left(P_t^{US} Y_t^*\right)}_{\text{scale}} + \underbrace{P_t^{US} Y_t^* \, \tfrac{\phi_U}{\mu_t} \, d\ln\left(\tfrac{1}{\mu_t}\right)}_{\text{markup / MC pass-through}}. \tag{42}$$

The composition term captures reallocations of sales toward exports ($ds_{X,t}$); the scale term reflects expansions/contractions of nominal sales $P_t^{US} Y_t^*$; and the markup term says that when marginal costs rise and μ_t falls, imports (being part of costs) absorb a larger fraction of sales.

US impatience (discount-factor) shock: A fall in the US discount factor raises US demand and marginal costs, so the US price level and output both increase; the dollar appreciates on impact. In (42), the scale term is negative because $P_t^{US} Y_t^*$ expands while the economy is import-intensive at the margin $\left(s_{X,t} < \phi_U/\mu_t\right)$. The markup term is also negative: higher marginal costs reduce μ_t, increasing the import share ϕ_U/μ_t in sales. The composition term is negative as well: the stronger dollar and higher US prices shift EA demand away from US varieties (Armington, (29)), lowering $s_{X,t}$. Hence all three forces deteriorate the US trade balance, consistent with the IRFs for the impatience shock in Figures 16 and 17.

US monetary policy tightening: A contractionary policy shock lifts the policy rate, raises the real rate, and depresses US consumption; marginal costs fall and disinflation sets in. In (42), the scale term becomes positive because

$P_t^{US} Y_t^*$ declines and $s_{X,t} < \phi_U/\mu_t$. The markup term is also positive: lower marginal costs raise μ_t, reducing the import share ϕ_U/μ_t in sales. The composition term turns negative—dollar appreciation still dampens EA demand for US goods, but this effect is dominated by the scale and markup terms. The trade balance therefore improves on impact, matching the IRFs for the monetary shock in Figures 18 and 19.

5.6.3 Model responses to US impatience shock

Figures 16 and 17 plot the variable responses to a US impatience (discount-factor) shock. A fall in the US discount factor brings US consumption forward, raising demand, marginal costs, and — via the NKPC — inflation in the United States. With Calvo pricing, the level of US tradable good price increases gradually. Monetary policy reacts endogenously: the US policy rate rises under the Taylor rule, lifting also the real rate according to the Fisher equation. The rise is the real interest rate is reflected in the EA Euler equation; the higher real return raises the EA household's effective intertemporal price of current consumption. This motivates the EA household to postpone consumption and purchase US household-issued bonds, thus enabling the external financing of the US trade deficit, which leads the US to incur a negative net foreign asset position and the EA a positive one. Consistent with UIP, the dollar appreciates on impact; the expected US inflation and consumption differentials exceed the EA's.

With both stronger dollar and higher US tradable good price, the price of the US intermediate input (P^{US}) rises in euro terms and demand shifts away from US goods. With higher EA savings to accommodate higher US consumption, EA importer's output (equal to EA consumption) falls. By the EA labour–supply condition, lower consumption raises desired hours which exerts downward pressure on the real wage. Because the importer's marginal cost consists of an input share weighted combination of the US intermediate input price and the domestic wage, the importer faces cost-push from the imported US-input price but a countering wage compression; initially, marginal costs fall and higher P^{US} enters gradually. Once consumption rebounds, wages rebound. The EA NKPC maps the marginal cost movement together with expected inflation into a rise in EA inflation, followed by mild deflation when cost pressures dissipate and forward-looking firms lower future costs.

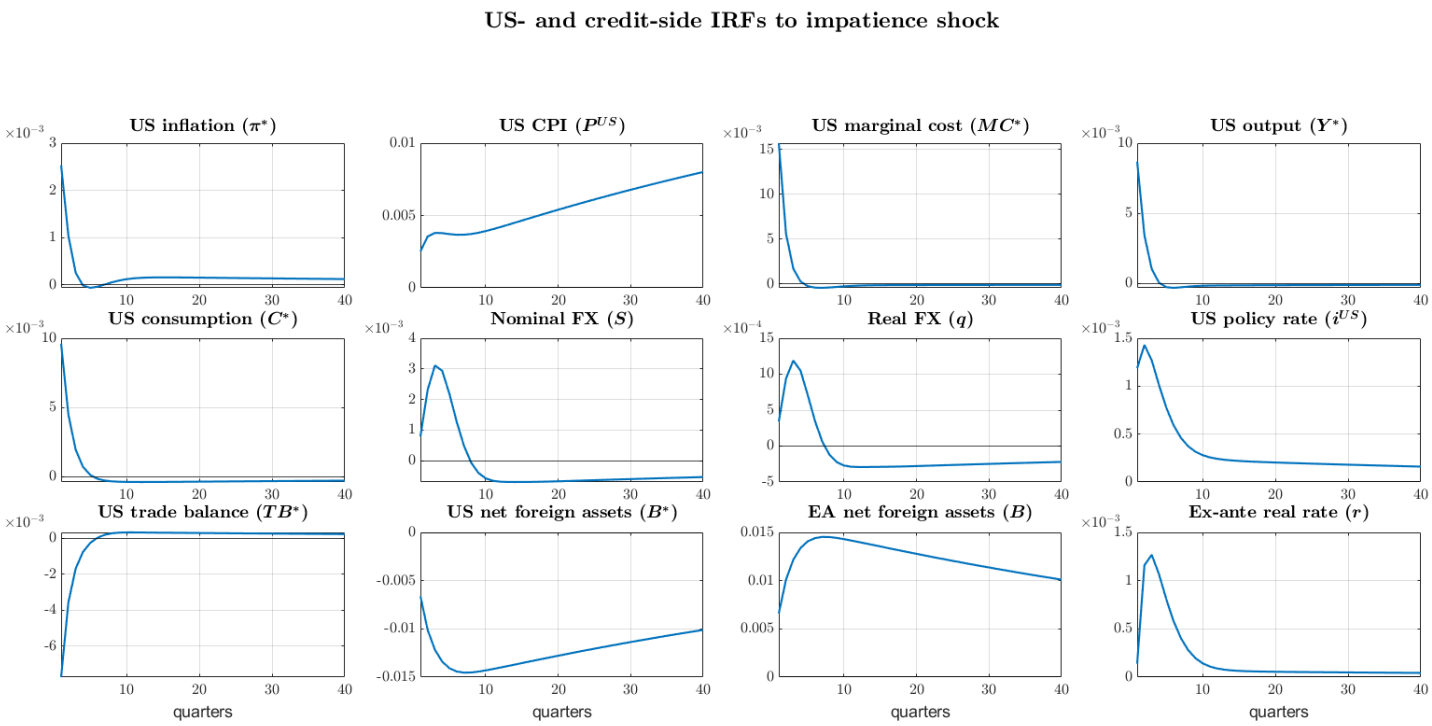


Figure 16: Impulse responses of the US block and credit-side to US household impatience shock of 1bp.

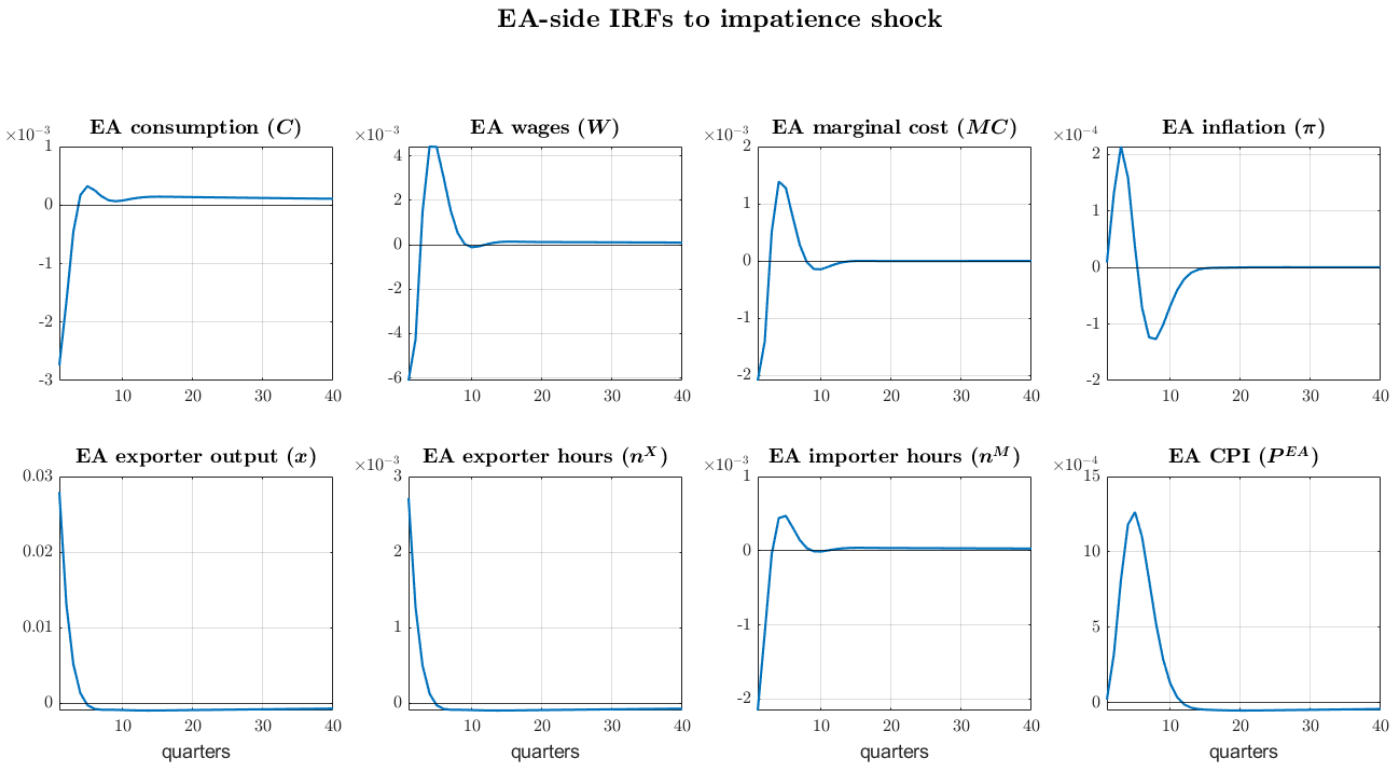


Figure 17: Impulse responses of the EA block to US household impatience shock f 1bp.

5.6.4 Model responses to US monetary policy shock

Figures 18 and 19 show equivalently the model's simulated responses to a US monetary policy shock (shock to the US Taylor rule). The monetary tightening lifts the US nominal rate on impact and, with it, the real rate. Higher real interest

rates compress domestic consumption by the US Euler, putting in motion reverse dynamics compared to the US impatience shock: US consumption and output fall, tradable firm's marginal costs drop, which generates disinflation by the US NKPC. With Calvo pricing the US tradable good price drifts gradually down toward its new lower level. US imports from the EA fall substantially more than its exports to the EA (US demand falls by far more than EA demand), resulting in a US trade surplus.

The interest rate hike triggers an immediate dollar appreciation (both nominal and real). On the asset side, tighter US policy raises the return on the internationally traded bond, which incentivises saving in both economies. The UIP balances the households' saving incentives, as the immediate dollar appreciation implies future dollar depreciation, lowering the real return in euro terms, such that the bond market clears.

On the EA-side, the exporter output (xstar) drops, while the importer output – equal to EA consumption (C) – fluctuates from negative to positive within notably smaller ranges, since the prices of imported intermediate inputs (P^{US}) fall yet dollar appreciates, while at the same time domestic input prices (EA wages) fluctuate with the total EA hours worked – on the net the drop in EA wages generates a drop in marginal costs of the EA importer. By the EA NKPC, EA inflation rises mildly due to the forward-looking inflation expectation term, and then reverses to move to zero. The scales of response in the EA are notable smaller than in the US, with the most notable impact on EA exporter activity and through this, the wages.

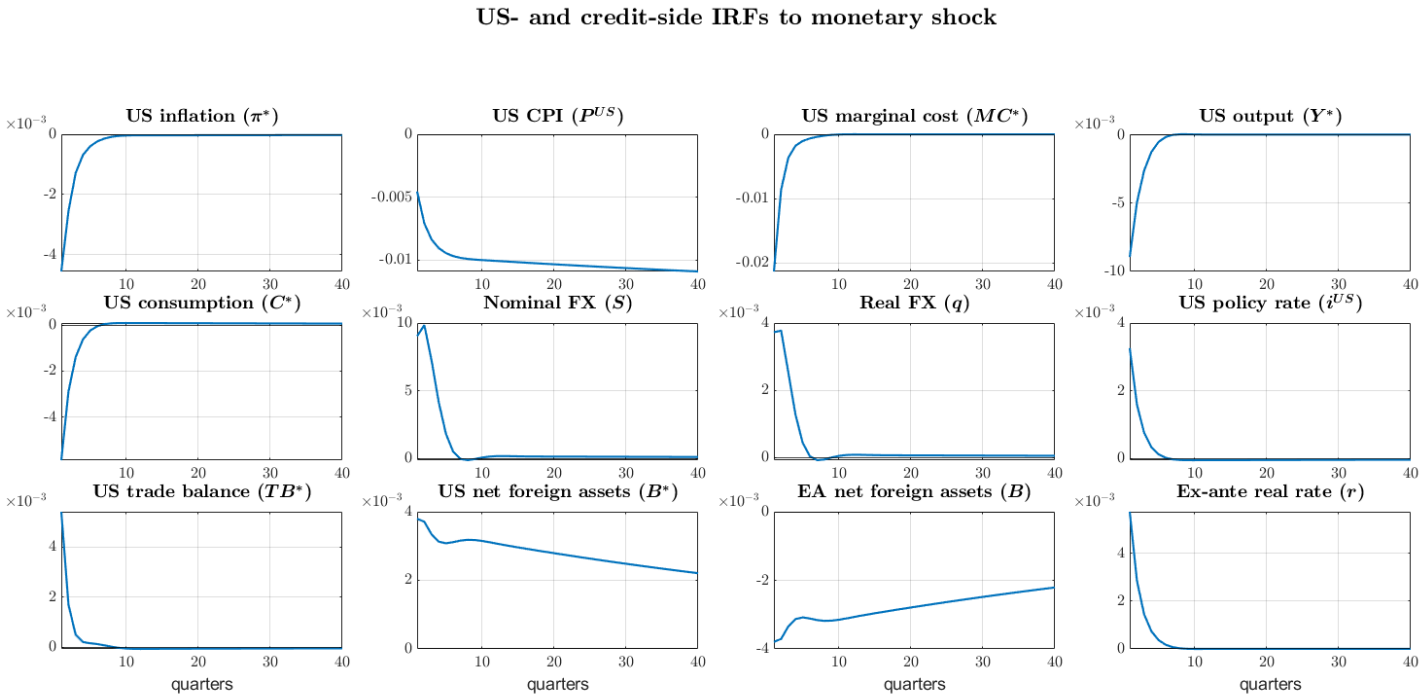


Figure 18: Impulse responses of the US block and credit-side to US monetary shock of 50 bps.

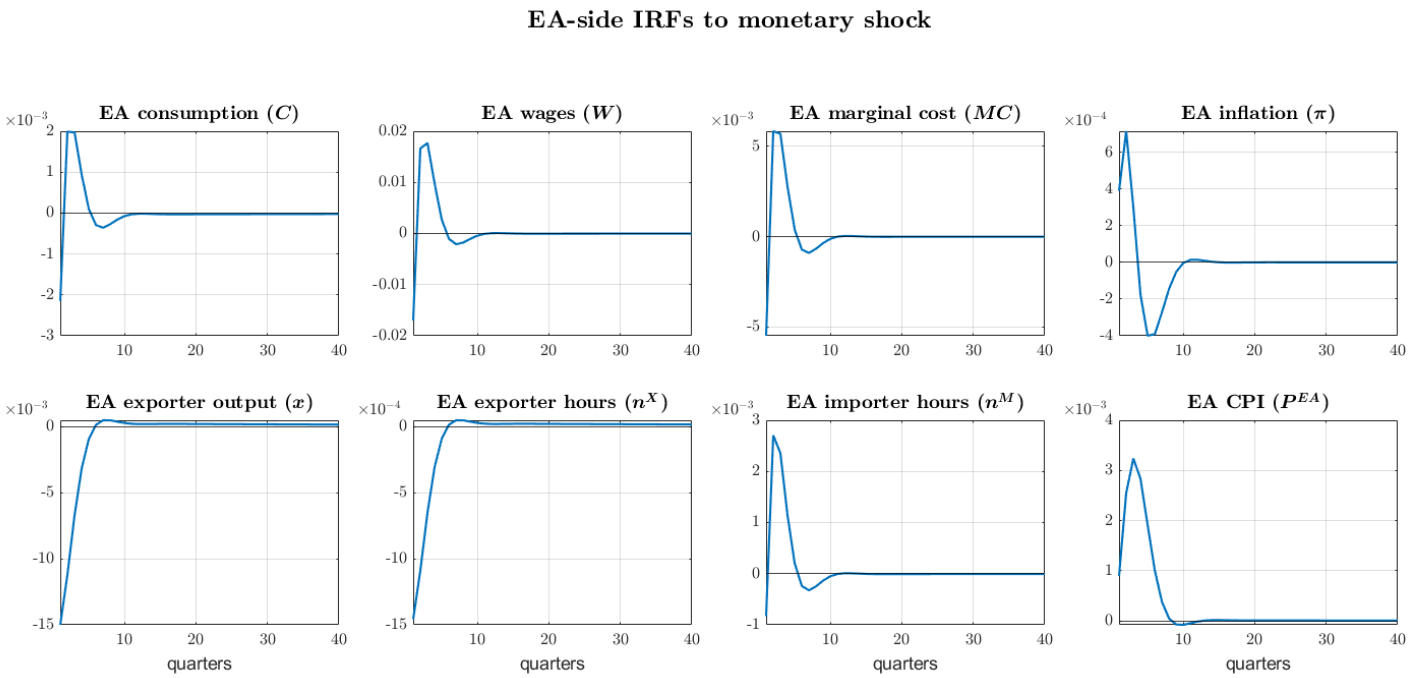


Figure 19: Impulse responses of the EA block to US monetary shock of 50 bps.

6 Conclusion

The paper estimated the effect of Fed news shocks on Euro Area production empirically through panel local projections and rationalised the findings through the mechanics of a two-country small-scale DSGE model. The usefulness of the evidence brought forth are twofold. First, we gained knowledge on the divergence of *Euro Area business cycles* when the US expansion takes off, and specifically about the real economic propagation mechanism of the specific US demand shock, communicated through the central bank, into EA activity. The US demand shock transmits upstream, from customer to supplier, as traditionally understood. Equally importantly, the US economic upturn has a global reach visible in a wide range of international prices, which ripple downstream as a cost-push shock to firms *competing* for inputs with the expanding US economy. In sum, while the positive Fed news shock predicts a positive outlook for the European suppliers of the US economy, it penalises the European trade partners that rely ultimately on the US economy as a source of inputs; hence we see the economic activity of these two groups of industries taking divergent paths.

The effects of the Fed information shocks on EA production were contrasted with the equivalent effects of exogenous changes in Fed monetary policy. Interestingly the EA industries' trade links with the US appear to be less consequential for the impact of the Fed monetary policy on EA production. This stands in stark contrast with the evidence that US trade links are decisive for the Fed information effects on Europe. European industries respond rather homogeneously to the Fed monetary shocks, which points to monetary effects arising through changes in absolute and relative prices affecting EA economic activity more broadly, as opposed to trade links that appear to be the driver of heterogeneity among European industry-level responses.

Second, the existence of the Fed news shocks as a distinct macroeconomic demand shocks bears economically meaningful implications on the role of the policy-maker. The identification strategy of the Fed news shocks, which are believed to anticipate changes in the US business cycle, relies on high-frequency stock market reactions and calls

into question how the shocks materialise from a real economic point of view. These shocks are, by now, well-familiar to the literature.[7] Yet, relatively little space is dedicated to what are the real economic outcomes that they stir, from an international macroeconomic point of view. The empirical findings serve to establish the connection between the stock price reactions during the Fed announcements and the ensuing global macroeconomic outcomes. This supports the identification assumption that stock markets have the ability to process central bank announcements efficiently.

From a policy-making perspective, the results bring awareness about the full set of tools available to the central bank. Besides the more concrete ability of the central bank to affect financial conditions through the policy rate, asset purchases etc., and the *fairly clearly defined* policy tool of providing forward-guidance about its future policies, there is an increasing awareness of the central bank's role of providing guidance on the macroeconomic outlook outside its policy remit. In other words, as a credible agent, the central bank has the *less well defined* capacity to provide guidance to the public on the intransparent developments underway in the economy and thus cement agents' beliefs. In a world of abundant information that require processing to become an economic estimate, the public can obviously benefit from a point of reference that anchors its predictions. This guidance, especially when used amidst uncertainty to affect the public's beliefs, can prove a powerful tool for changing agents' expectations which are known to be key for any forward-looking decisions omnipresent in the economy. It takes a credible agent to perform this role. This highlights the need for central bank credibility in preserving a guiding and belief-anchoring role in the institution's policy toolkit.

[7] 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 analysis.

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APPENDICES

A Trade related variables' construction

A simplified structure of a world input-output table is shown in Figure 20.

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

Figure 20: The structure of a world input-output table. Source: 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:

$$FW_{ij}^{r} = \frac{\sum_{s=1}^{S} F_{ij}^{rs}}{VA_i^r} + \frac{\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{s=1}^{S} a_{ik}^{rl} F_{kj}^{ls}}{VA_i^r} + \frac{\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{s=1}^{S} a_{ik}^{rl} a_{km}^{lt} F_{mj}^{ts}}{VA_i^r} + \ldots \tag{43}$$

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:

$$Y = F + AY = F + AF + A^2F \ldots \tag{44}$$

$$\Rightarrow Y = [\mathbf{I} - \mathbf{A}]^{-1} F \tag{45}$$

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:

$$VA = \mathbf{V}\mathbf{A}^{-1}[\mathbf{I} - \mathbf{A}]^{-1} F \tag{46}$$

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}):

$$va^r_{ij} = \mathbf{VA}^{-1}[\mathbf{I}-\mathbf{A}]^{-1} f_j \tag{47}$$

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.:

$$fw^r_{ij} = va^r_{ij}[VA^r_i]^{-1} \tag{48}$$

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:

$$BW^s_{ij} = \frac{\sum_{s=1}^{S} F^{sr}_{ji}}{VA^s_j} + \frac{\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{s=1}^{S} a^{sl}_{jk} F^{lr}_{ki}}{VA^s_j} + \frac{\sum_{m=1}^{M}\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{t=1}^{T}\sum_{s=1}^{S} a^{sl}_{jk} a^{lt}_{km} F^{tr}_{mi}}{VA^s_j} + \ldots \tag{49}$$

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^s_j, 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).

B Data appendix

Table 2: Summary of data for control variables

Variable	Source	Periods	Details
Euro stoxx 50 volatility index (VSTOXX)	STOXX Ltd www.stoxx.com	2000m1-2019m12	Monthly values averaged from daily closing value of the index. Series key: V2TX.
VIX index	Chicago Board Options Exchange, retrieved from FRED	2000m1-2019m6	Monthly, average. Series key: VIXCLS.
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	IMF, retrieved from FRED	2000m1-2019m12	Global price of Brent Crude. Series key: POILBREUSDM. Real values obtained dividing by US CPI; series key CPIAUCSL (also via FRED).
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 [GS2].
Eonia	ECB	2000m1-2019m12	Series key: FM.M.U2.EUR.4F.MM.EONIA.HSTA
Excess bond premia	Gilchrist and Zakrajsek (2012)	2000m1-2019m12	
EA real activity index	Scotti (2016)	2000m1-2019m12	

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

Table 3: Summary of data for main variables

Variable	Source	Periods	Details
EA industrial production	Eurostat	2000m1-2017m12	Price-adjusted output of industry; index, 2010=100. Seasonally and calendar adjusted. Series code: sts_inpr_m.
Fed information shocks	marekjarocinski.github.io	2000m1-2019m6	shocks obtained with the median rotation that implements the sign restrictions
Fed monetary shocks	marekjarocinski.github.io	2000m1-2019m6	shocks obtained with the median rotation that implements the sign restrictions
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. (2015))	2000-2014	Annual data.
Forward participation	World Input-Output Database (WIOD), Timmer et al. (2015))	2000-2014	Annual data.
Upstreamness	World Input-Output Database (WIOD), Timmer et al. (2015))	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 In-

C Open economy model

C.1 Market Clearing & Identities

US final good:

$$Y_t = C_t^* + m_t. \tag{50}$$

US production:

$$Y_t = A_t \, (n_t^*)^{1-\phi_U} \, (x_t^*)^{\phi_U}. \tag{51}$$

EA importer flow identity (cost vs. composite):

$$S_t \, m_t + W_t^E \, n_{M,t} = \mathrm{UC}_t^E \, C_t = P_t^E \, \mathrm{MC}_t^E \, C_t. \tag{52}$$

EA labour market:

$$n_t = n_{M,t} + n_{X,t}. \tag{53}$$

EA goods market:

$$y_t(j) \; = \; c_t(j). \tag{54}$$

Price levels:

$$P_t^E = \frac{\pi_t^E}{\bar{\Pi}} \, P_{t-1}^E, \qquad P_t^{US} = \frac{\pi_t^Y}{\bar{\Pi}} \, P_{t-1}^{US}, \qquad p_t^{US,\mathrm{EUR}} = S_t \, P_t^{US}. \tag{55}$$

Exporter pricing linkage:

$$p_{x,t}^E = S_t \, \mathrm{pxusd}_t, \qquad W_t^E \, n_{X,t} = (1-\mu_E) \, p_{x,t}^E \, x_t^*. \tag{56}$$

NFA and trade:

$$\text{Exports (EA to US):} \quad X_t^{US} = m_t, \tag{57}$$

$$\text{Imports (US from EA):} \quad M_t^{US} = \mathrm{pxusd}_t \, x_t^*, \tag{58}$$

$$\text{Trade balance (US):} \quad \mathrm{TB}_t = X_t^{US} - M_t^{US}, \tag{59}$$

$$\text{US NFA law of motion:} \quad b_t = \frac{i_{t-1}^{US}}{\pi_t^Y} \, (1 + \mathrm{prem}_{t-1}) \, b_{t-1} + \frac{\mathrm{TB}_t}{\bar{Y}}, \qquad \mathrm{prem}_t = \psi_b (b_{t-1} - \bar{b}). \tag{60}$$