Global supply chain pressures, inflation, and implications for monetary policy

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Challenges for Monetary Policy Transmission
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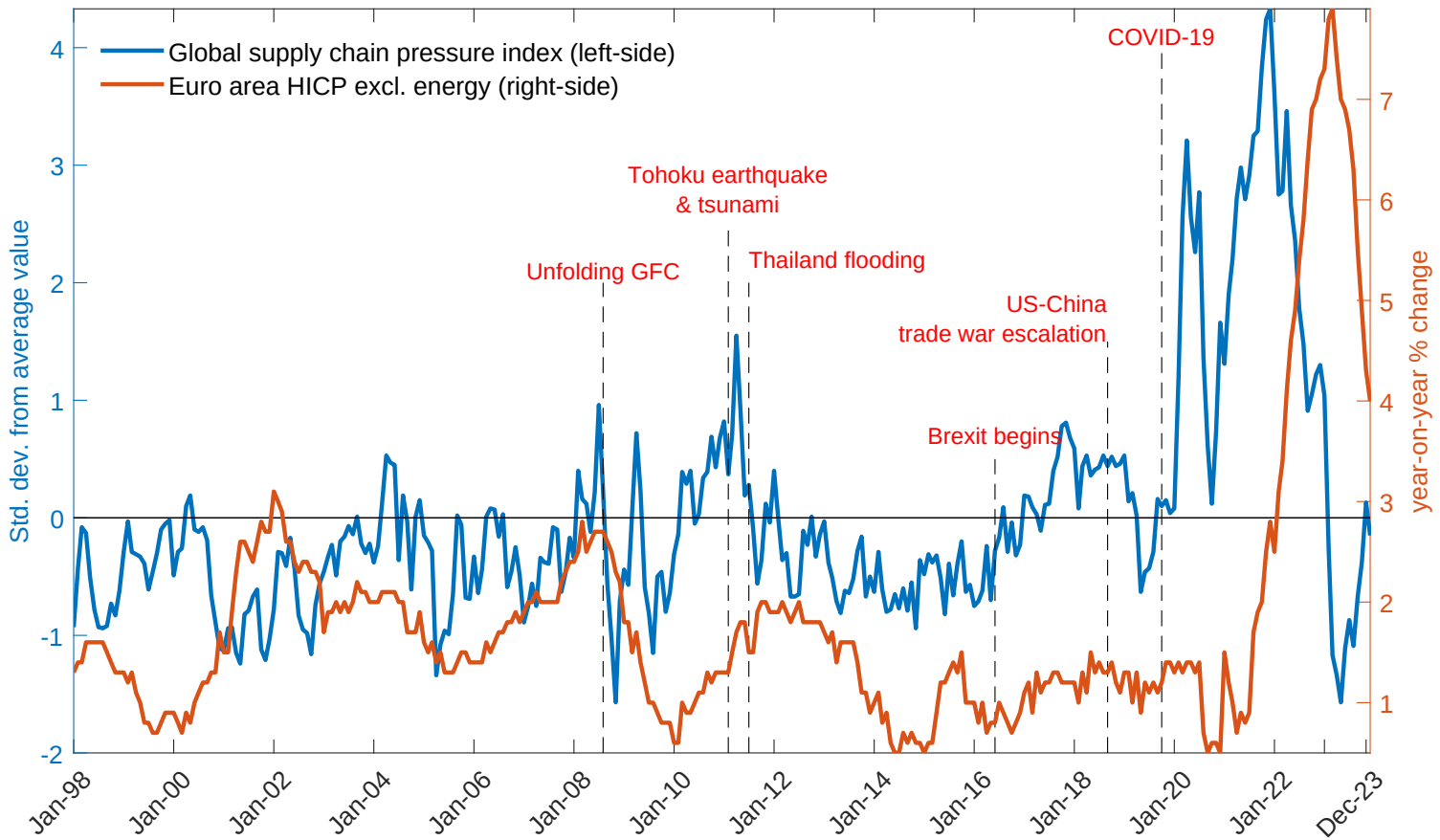
The views expressed do not necessarily reflect the official position of the De Nederlandsche Bank or the Eurosystem.

Global supply chain pressures intensified during COVID-19...

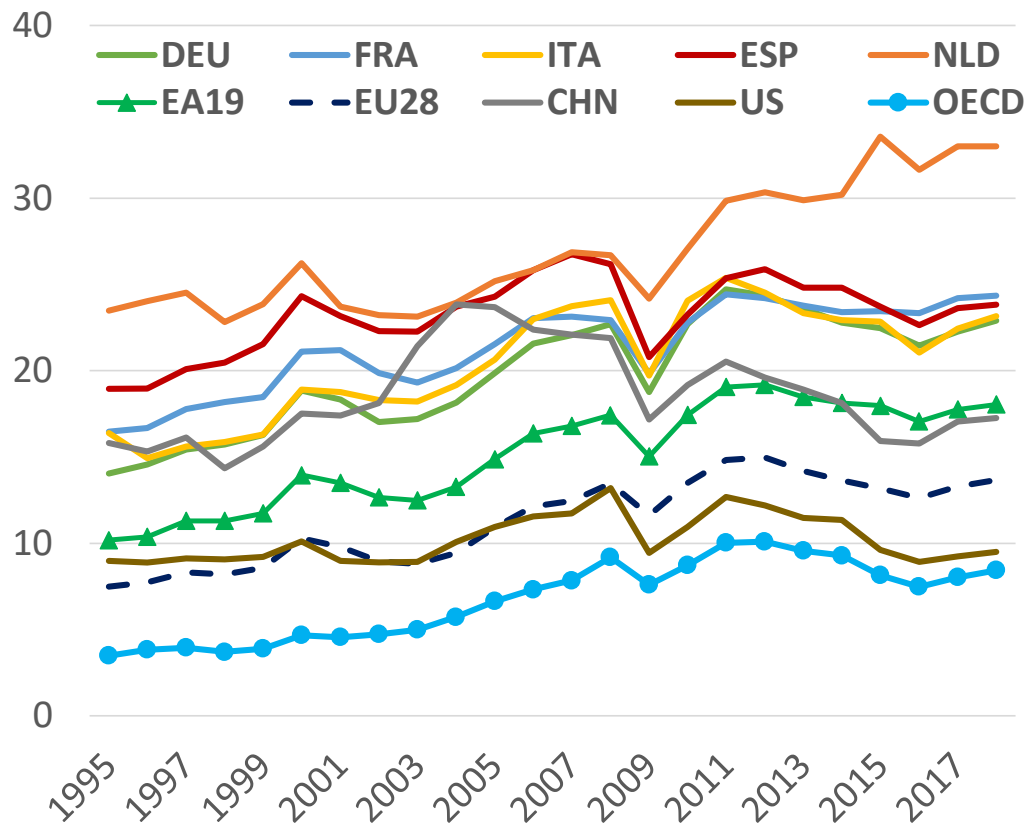
Figure 1: ...and seem to be related to inflation



Source: Federal Reserve Bank of New York (Benigno et al., 2022) and Eurostat.

High participation in global supply chains

Figure 2: Foreign value added embodied in exports, as a % of total gross exports



Source: OECD, TiVA 2021 edition (last year available is 2018), own computations.

What we do in this paper

- Quantify empirically how much global supply chain pressures contribute to euro area inflation
  1. Phillips curve analysis
  2. Bayesian structural VAR analysis

- Study theoretically what they imply for monetary policy
  - Two-country New Keynesian model featuring global supply chains

What we find

- Global supply chain pressures contribute positively and significantly to euro area inflation

- Shocks to global supply chain pressures...
  - were the dominant driver of euro area inflation in 2022
  - have a highly persistent and hump-shaped impact on inflation

- Optimal monetary policy response to global-supply-induced inflation is a non-linear function of the degree of global value chain participation

Related literature

- Our work connects to various strands of literature

1. Relative importance of supply- and demand-side factors to recent inflation surge
   - Andriantomanga et al. (2022), Ferrante et al. (2022), Finck and Tillmann (2022), Shapiro (2022a,b), di Giovanni et al. (2022, 2023)
2. Global supply chain and monetary policy implications
   - Gong et al. (2016), Ozdagli and Weber (2017), Pastén et al. (2020), Wei and Xie (2020)
3. Impact of globalization on inflation
   - Auer et al. (2017), Auer et al. (2019), Forbes (2019) , Ascari and Fosso (2021)
4. Supply chains or input-output linkages as an amplification mechanism for shocks
   - Huang and Liu (2001), Acemoglu et al. (2016), Carvalho and Tahbaz-Salehi (2019), Acemoglu and Tahbaz-Salehi (2020), Frohm et al. (2021), Ghassibe (2021)

Empirical analysis:

Impact of global supply chain pressures on euro area inflation

Empirical analysis: a two-pronged approach

1. Phillips curve analysis
   - Estimate standard Phillips curve for the euro area
   - Compare against Phillips curve model augmented with GSCPI

2. Bayesian structural VAR analysis
   - Identify shocks to global supply chain pressures
   - ...and estimate their impact on euro area inflation

Global supply chain pressures important factor driving euro area inflation

Table 1: Euro area Phillips curve, 2005M4-2023M8

	(1)	(2)	(3)	(4)
Dependent variable: HICP	Headline	Core	Headline	Core
Industrial production	0.011***	0.004**	0.012***	0.05***
	[0.004]	[0.002]	[0.004]	[0.008]
1-year ahead inflation expectations	0.06	0.038	0.109**	0.79*
	[0.049]	[0.03]	[0.049]	[0.102]
GSCPI			**0.095*** **	**0.379*** **
			[0.023]	[0.049]
Adjusted R-squared	0.976	0.95	0.978	0.885
BIC	122.94	-62.45	105.67	473.38
Obs.	221	221	221	221

Notes: Core HICP = HICP excl. energy. All variables expressed as y-o-y % changes, except for the GSCPI (std. dev. from mean). *, ** and *** indicate significance at 10%, 5% and 1%. Standard errors in brackets. Estimates of constant and coefficients on lags of dependent variable are omitted.

The BVAR model: data

- Monthly euro area data, covering the 2000M1-2023M7 period
- Model contains five euro area aggregate variables plus GSCPI:
  1. Industrial production (y-o-y % change)
  2. HICP excl. energy (y-o-y % change)
  3. Shadow rate (from Krippner, %)
  4. Real effective exchange rate (w.r.t. EA's 42 partners, y-o-y % change)
  5. Real price of oil Brent (deflated by HICP, y-o-y % change)
  6. **GSCPI** (std. dev from mean)
- 12 lags, constant, and standard Minnesota priors

The BVAR model: sign, zero and narrative restrictions

- Main focus: shock to global supply chain pressures, and relative importance compared to other shocks (demand, domestic supply, monetary policy, exchange rate, oil price)

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- Distinguishing between domestic and global supply shock:
  - Both drive economic activity and prices in opposite directions
  - ...but GSCPI does not respond contemporaneously to domestic supply shock
  - ...and responds positively on impact to global supply chain pressure shock

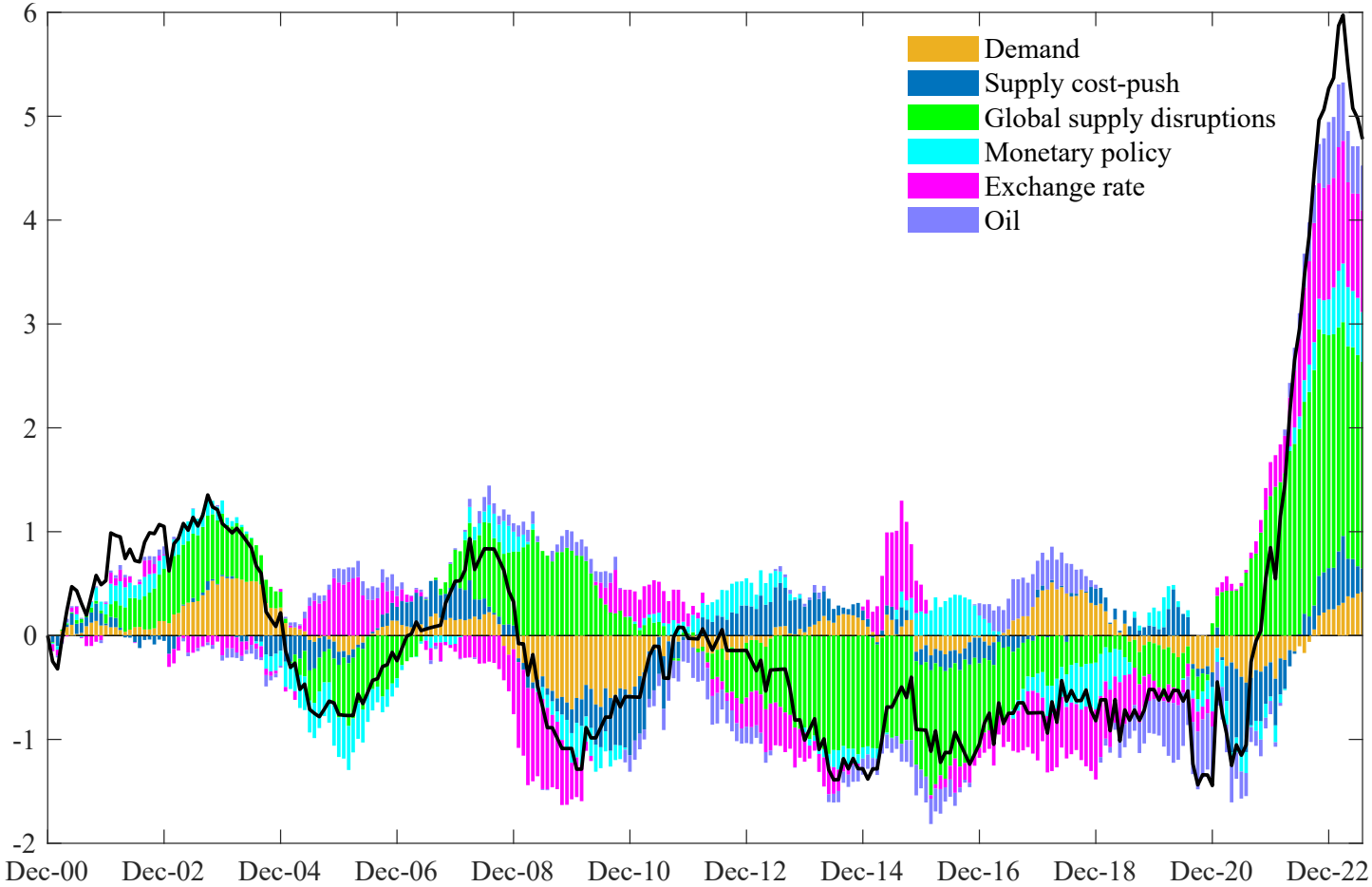
The BVAR model: sign, zero and narrative restrictions

- Main focus: shock to global supply chain pressures, and relative importance compared to other shocks (demand, domestic supply, monetary policy, exchange rate, oil price)
- Distinguishing between domestic and global supply shock:
  - Both drive economic activity and prices in opposite directions
  - ...but GSCPI does not respond contemporaneously to domestic supply shock
  - ...and responds positively on impact to global supply chain pressure shock
- Key narrative restrictions:
  - Global supply pressure shocks have a positive sign in March 2011 (Tōhoku earthquake), March 2021 (Suez Canal) and April 2022 (Shanghai Backlog)
  - Largest contribution to forecast errors of GSCPI in March 2011, April 2020 and November 2021 (COVID-19) attributed global supply chain pressure shocks

see details on all restrictions

Recent surge in inflation mostly due to shocks to global supply chain pressures

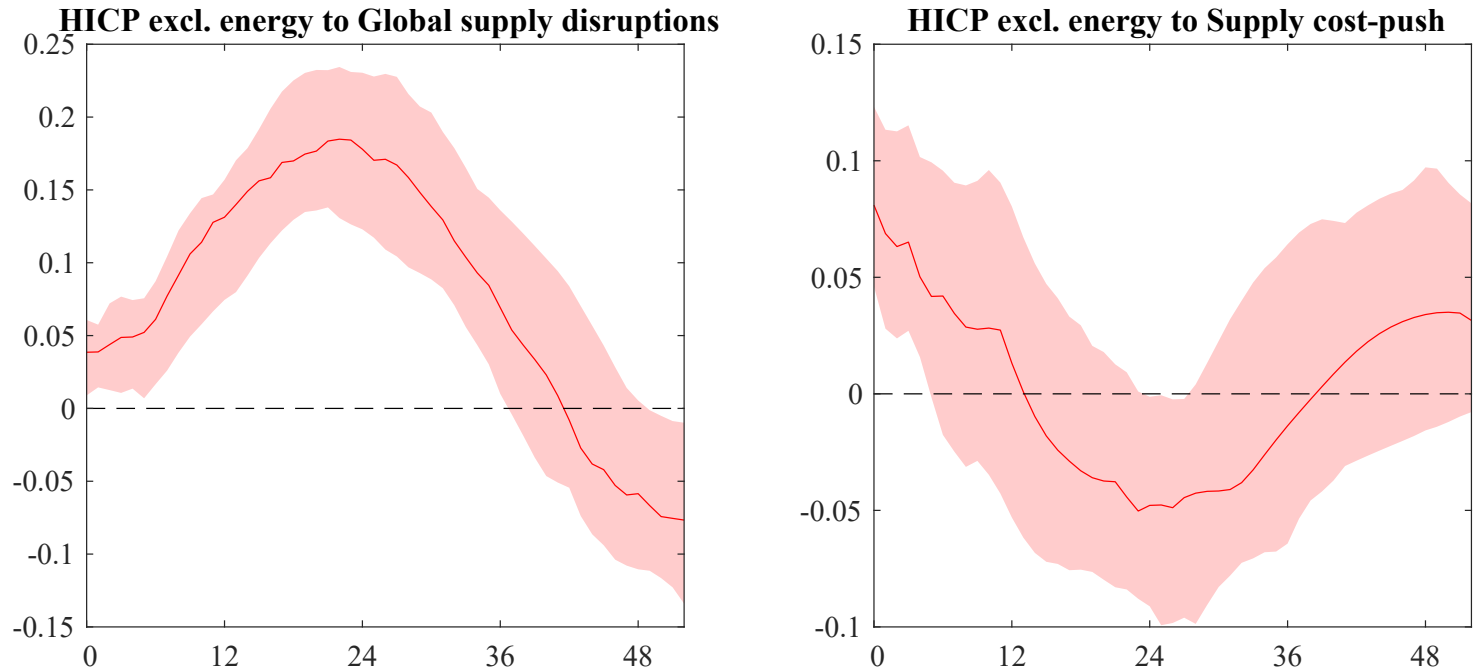
Figure 3: Historical shock decomposition of euro area core inflation



Notes: Core inflation measured by y-o-y % change of HICP excl. energy. Units expressed in deviations from mean.

Inflation response to global supply shock more persistent than to domestic supply shock

Figure 4: Response of core inflation to global and domestic supply shock



Notes: The figure shows the response of euro area HICP (excluding energy), y-o-y % change, to a one standard deviation global supply chain pressure shock (left panel) and to a one standard deviation supply cost-push shock (right panel). The figure reports the median response (red solid line) and a 68% confidence band.

▸ IRFs global supply shocks

Empirical analysis: summing up

- Global supply chain pressures contribute positively and significantly to euro area inflation

- Shocks to global supply chain pressures...
  - were the dominant driver of euro area inflation in 2022
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Theoretical analysis:
Implications of global supply chain pressures for monetary policy

A model with trade in intermediate inputs

- Two-country New Keynesian model, **H**ome and **F**oreign (Benigno, 2009)
- Central bank:
  - Targets domestic CPI inflation and output gap
- Households:
  - Decide on consumption/savings and hours worked
  - Consume (hold) both Home and Foreign goods (bonds)
  - Incur costs when accumulating foreign bonds
- Firms:
  - Intermediate good firms (perfectly competitive)
  - Final good firms (monopolistically competitive)
  - Final good firms face price-setting friction a-la Rottemberg
  - Final goods produced using both Home and Foreign intermediate goods (Eyquem and Kamber, 2014)

The firm sector

- Intermediate goods, x_t:

$$x_t = z_{A,t} n_t \tag{1}$$

with n_t labor and $z_{A,t}$ productivity

- Final goods, $y_{H,t}$:

$$y_{H,t}(i) = \left[(1-\gamma)^{\frac{1}{\phi}} \left(\underbrace{x_{H,t}(i)}_{\text{Home intermediate goods}} \right)^{\frac{\phi-1}{\phi}} + \gamma^{\frac{1}{\phi}} \left(\underbrace{x_{F,t}(i)}_{\text{Foreign intermediate goods}} \right)^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{2}$$

with $\phi \geq 0$ the elasticity of substitution between $x_{H,t}$ and $x_{F,t}$

The firm sector

- Final goods firms' marginal costs, mc_t:

$$mc_t = \left[(1-\gamma) \left(p_{H,t}^{-1} \frac{w_t}{z_{A,t}} \right)^{1-\phi} + \underbrace{\gamma \left(q_t p_{H,t}^{-1} \frac{w_t^*}{z_{A,t}^*} \right)^{1-\phi}}_{\text{additional cost channel}} \right]^{\frac{1}{1-\phi}} \tag{3}$$

  with w_t real wage, q_t real exchange rate and $p_{H,t} \equiv P_{H,t}/P_t$

- Key parameter: $\gamma \in [0,1]$ measures the share of Foreign intermediate goods used in Home goods production

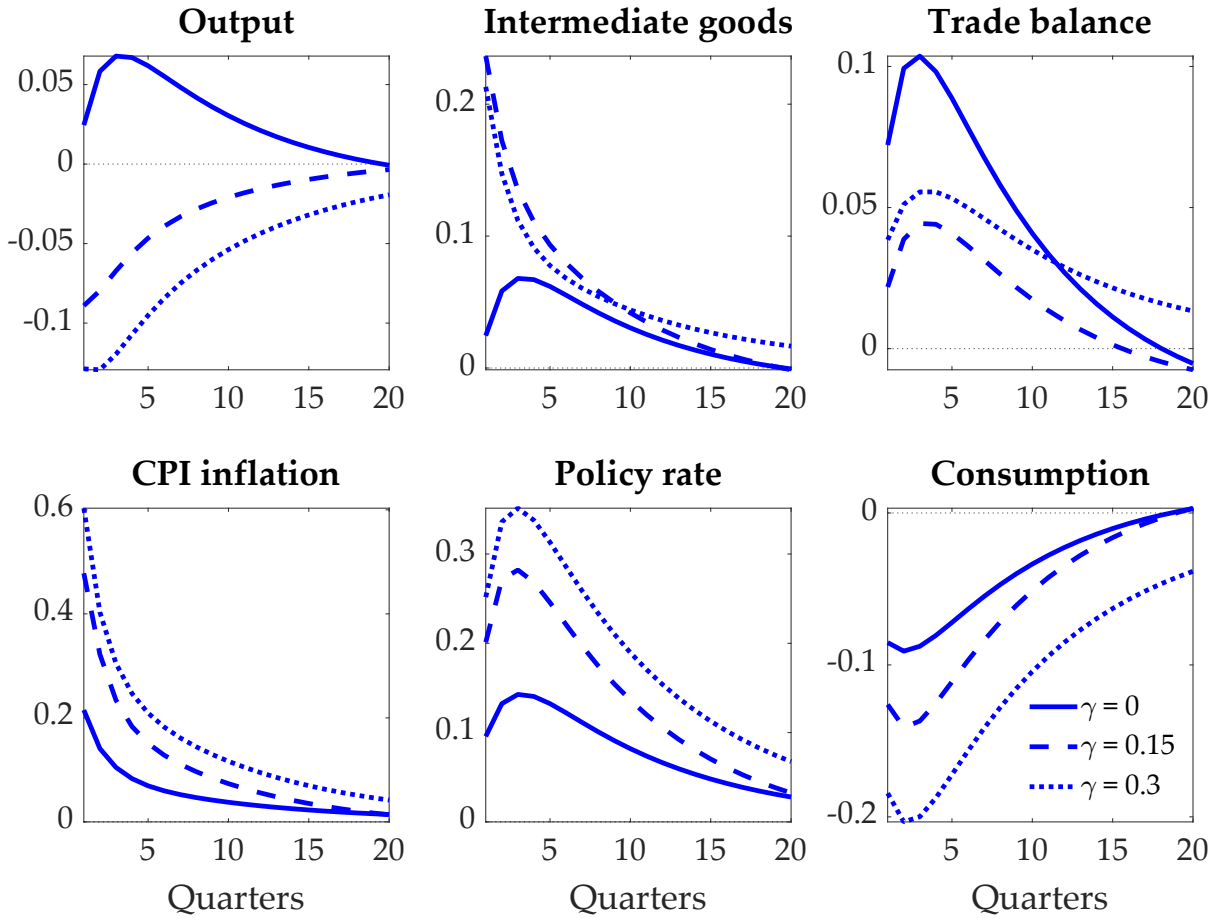
- Similar expressions apply for Foreign

Modeling global supply chain pressures

- Setting $\gamma > 0$ implies economy relies on global supply chains
- The **higher** is γ, the **higher** is GVC participation
- Global supply chain pressures approximated by negative shock to Foreign productivity, $z^*_{A,t}$
- When $z^*_{A,t} \downarrow$, supply of Foreign intermediate inputs available for the production of Home goods falls $\longrightarrow$ global supply chain pressures
- Severity of global supply chain pressures determined by γ

Is it a demand or supply shock?

Figure 5: Responses of Home variables to global supply pressure shock



Notes: Global supply chain pressure shock proxied by negative Foreign productivity shock. γ measures share of Foreign intermediate goods used in production of Home goods. Units expressed as percentage point deviation from steady state, except for CPI inflation and policy rate, which are expressed in annualized percentage points.

Is it a demand or supply shock?

- When $\gamma = 0$, global supply pressure shock $\approx$ **demand shock**:
  - Price of Foreign intermediate goods rises
  - Expenditure switching effect leads to increase in demand for Home goods
  - Home output and inflation rise, monetary policy tightens, consumption falls

- When $\gamma > 0$, global supply pressure shock $\approx$ **supply shock**:
  - Home inflation still rises, but Home output falls
  - Higher Foreign prices immediately pass-through to Home marginal costs
  - Home goods more expensive, demand for Home goods falls

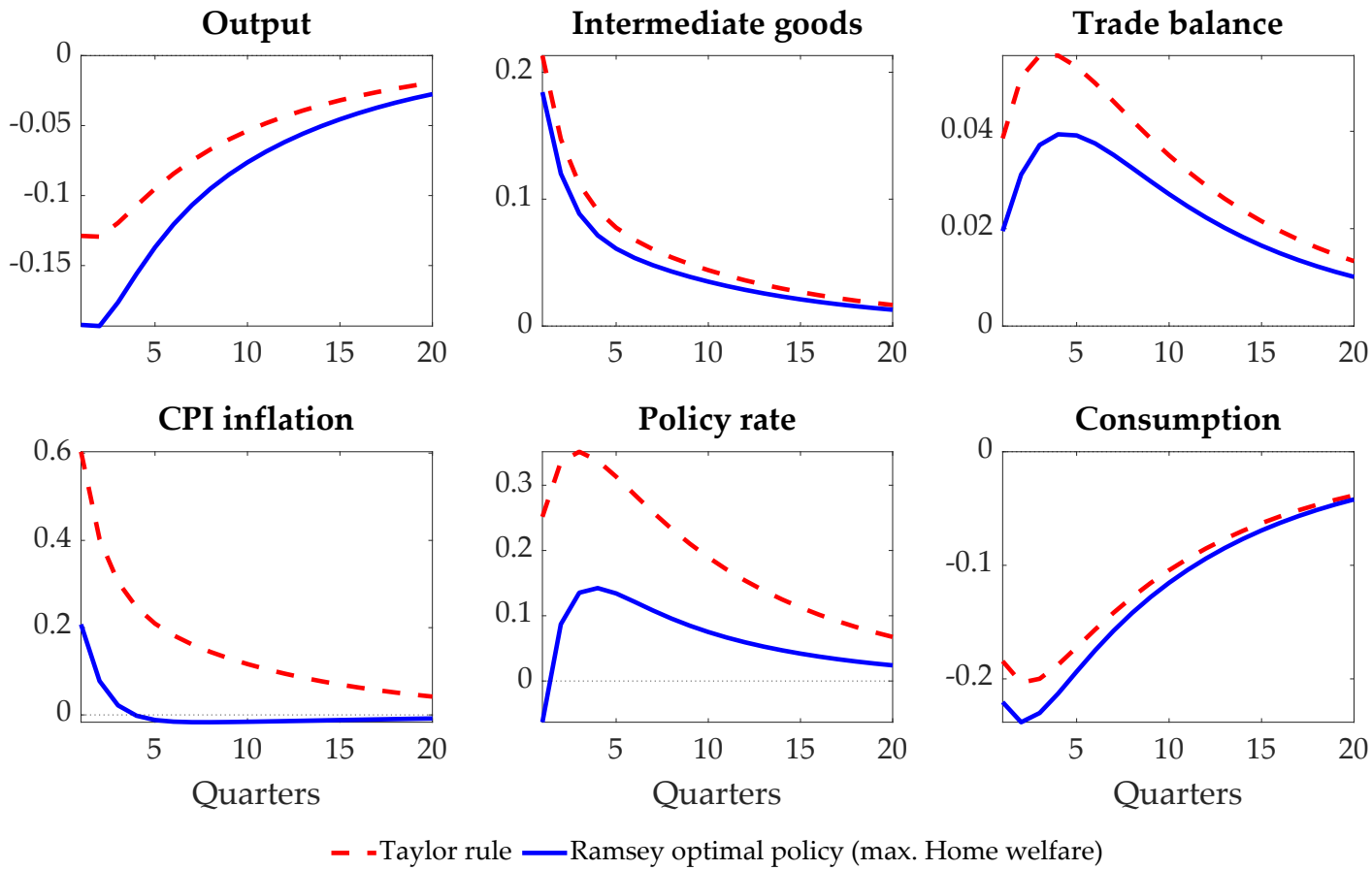
Implications for monetary policy trade-off

- Following a global supply pressure shock, the higher is γ...
  - the stronger is the cost channel
  - the greater is the rise in inflation
  - the larger is the drop in output

- Hence, when faced with global supply pressure shocks, higher reliance on global value chains poses a less favorable inflation-output stabilization trade-off to monetary policy

Optimal monetary policy implies a gradual tightening

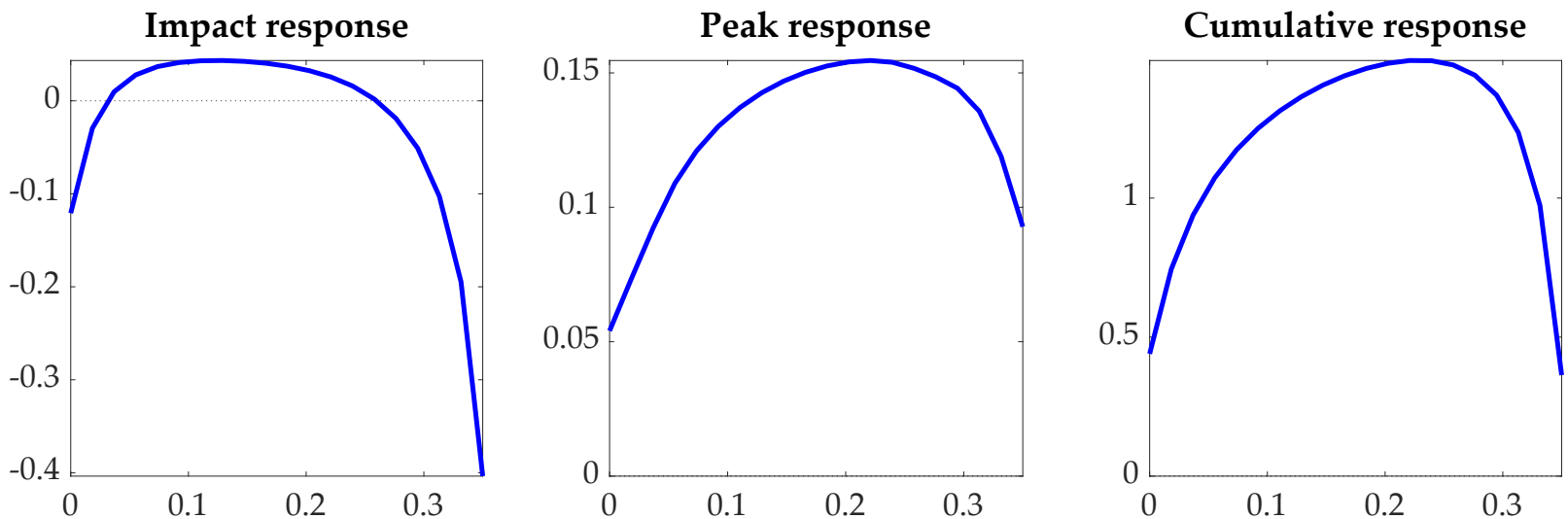
Figure 6: Responses of Home variables to global supply pressure shock ($\gamma = 0.3$)



Notes: Global supply chain pressure shock proxied by negative Foreign productivity shock. γ measures share of Foreign intermediate goods used in production of Home goods. Units expressed as percentage point deviation from steady state, except for CPI inflation and policy rate, which are expressed in annualized percentage points.

...and is a non-linear function of reliance on GVCs

Figure 7: Response of Home policy rate to global supply chain pressure shock under Ramsey optimal policy

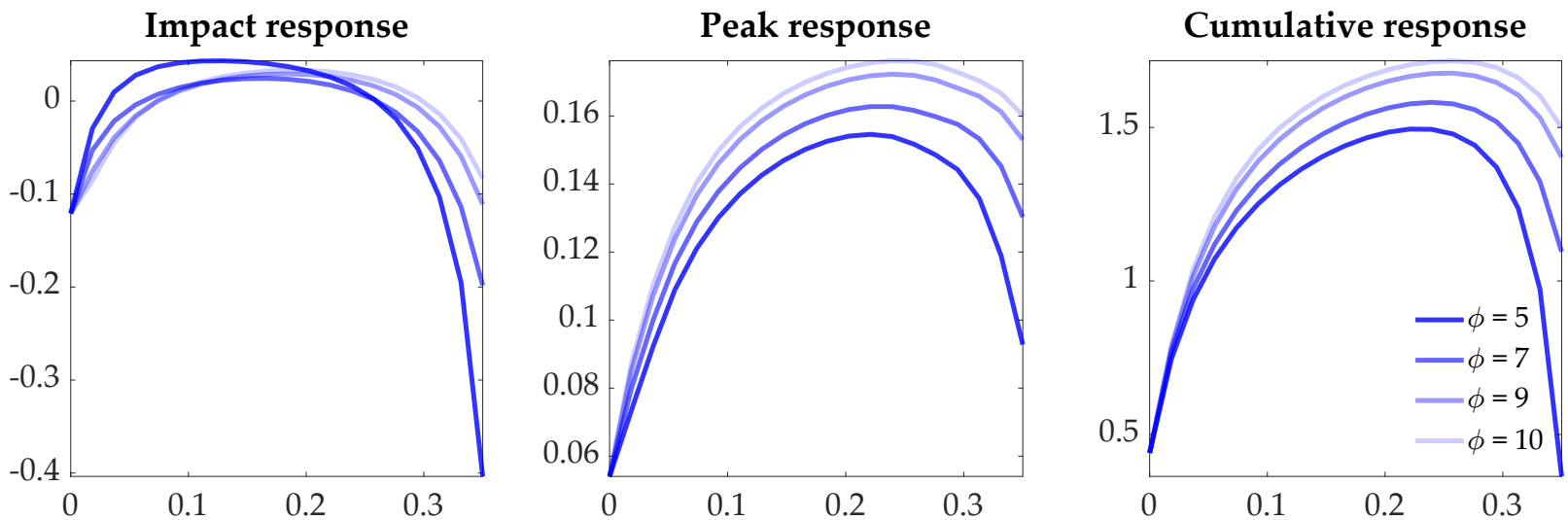


γ: share of foreign intermediate goods used in production of domestic final goods

Notes: Units expressed as annualized percentage points. Cumulative response measured over 5 years.

Higher substitutability allows for stronger tightening

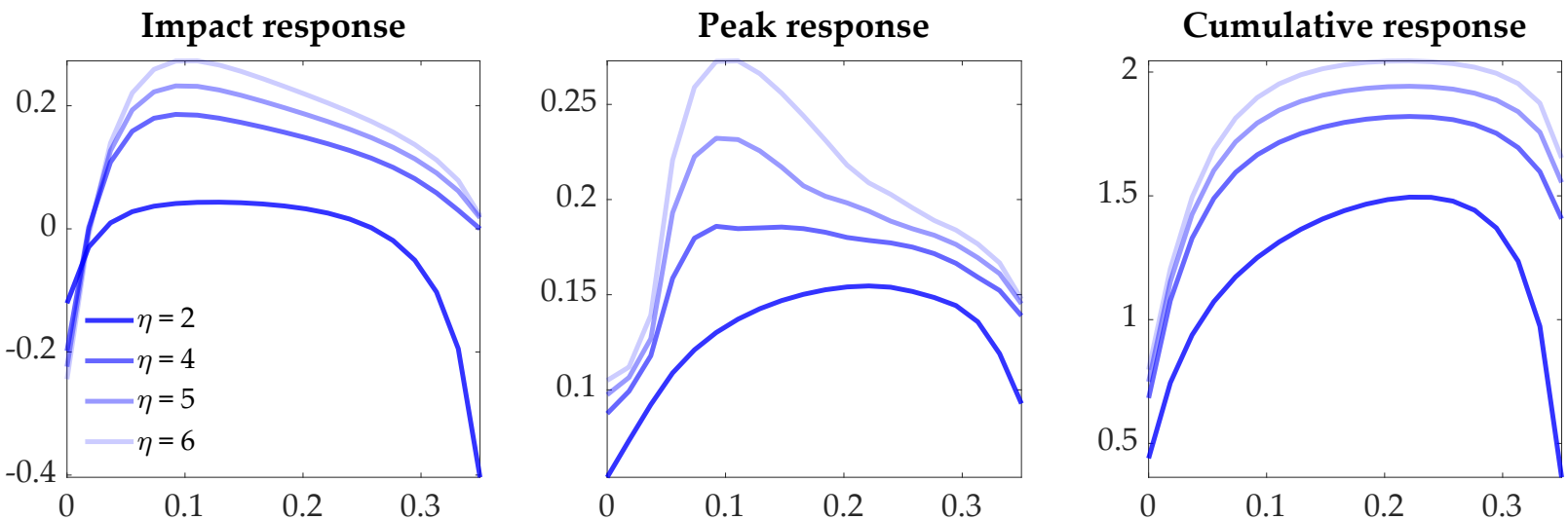
Figure 8: Response of Home policy rate to global supply chain pressure shock under Ramsey optimal policy



Notes: Units expressed as annualized percentage points. Cumulative response measured over 5 years. ϕ measures the elasticity of substitution between Home and Foreign intermediate goods.

Higher substitutability allows for stronger tightening

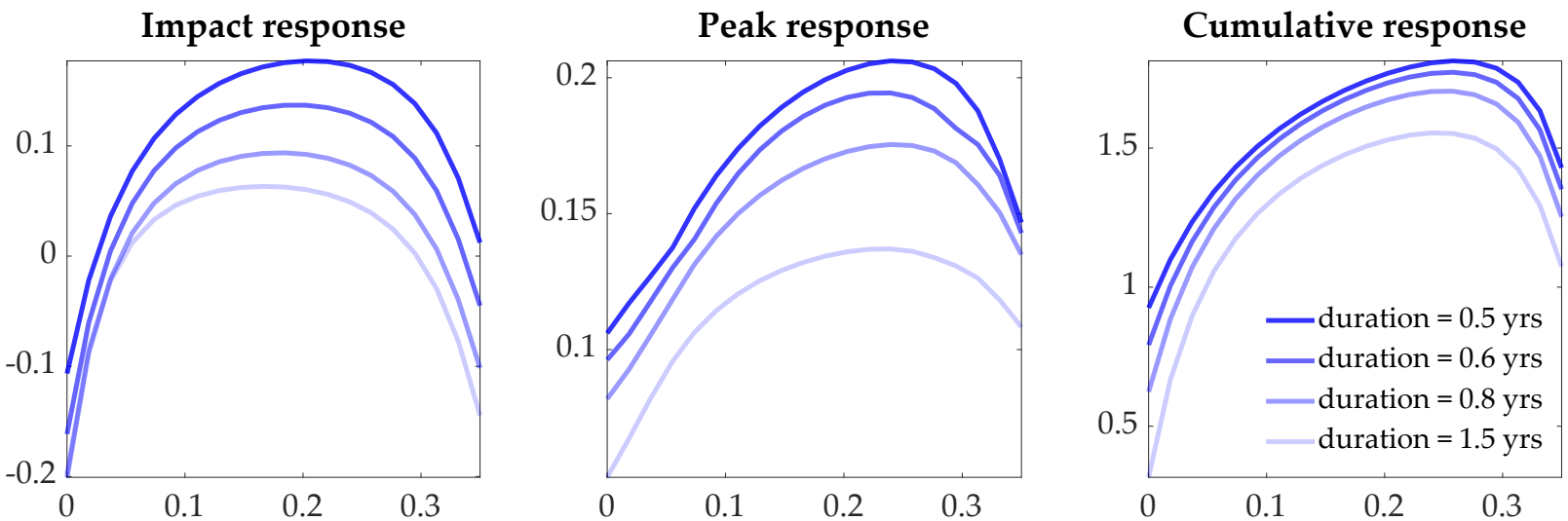
Figure 9: Response of Home policy rate to global supply chain pressure shock under Ramsey optimal policy



Notes: Units expressed as annualized percentage points. Cumulative response measured over 5 years. ϕ measures the elasticity of substitution between Home and Foreign final goods.

Higher price-stickiness requires weaker tightening

Figure 10: Response of Home policy rate to global supply chain pressure shock under Ramsey optimal policy



γ: share of foreign intermediate goods used in production of domestic final goods

Notes: Units expressed as annualized percentage points. Cumulative response measured over 5 years. 'duration' refers to the average duration of a price contract for final goods.

Theoretical analysis: summing up

- When a country relies on GVCs, a global supply pressure shock raises domestic inflation and reduces domestic output
- Higher reliance on GVCs worsens monetary policy trade-off between stabilizing inflation and output
- Ramsey optimal policy implies gradual tightening monetary policy in response to global-supply-induced inflation
- Optimal monetary policy response is...
  - a non-linear function of GVCs reliance
  - more aggressive when substitution towards domestic goods is easy
  - less aggressive when prices are more sticky

Conclusion

What we find

- Global supply chain pressures contribute positively and significantly to euro area inflation

- Shocks to global supply chain pressures...
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- Optimal monetary policy response to global-supply-induced inflation is a non-linear function of the degree of global value chain participation

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Background slides

The BVAR model: sign and zero restrictions

Table 2: Restrictions imposed (on impact) to identify the structural shocks

	Demand	Supply		Monetary	Exchange	Oil
		Domestic	**Global**	policy	rate	
Industrial production	+	-	-	-	-	-
HICP excl. energy	+	+	+	-	-	
GSCPI	0	0	+	0		
Shadow rate	+			+	-	
REER					+	
Real oil price		-				+

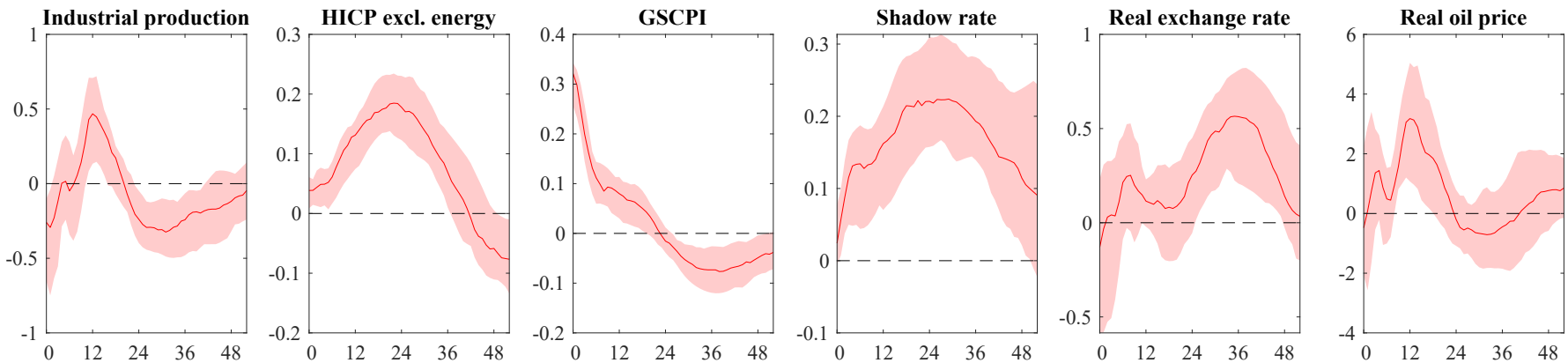
The BVAR model: narrative restrictions

- Impose also narrative restrictions to further discipline the parameter space (Antolín-Díaz and Rubio-Ramírez, 2018):
  - Demand shocks have a negative sign in March and April 2020 (COVID-19)
  - Global supply pressure shocks have a positive sign in March 2011 (Tōhoku earthquake), March 2021 (Suez Canal) and April 2022 (Shanghai Backlog)
  - Oil price shocks have a positive sign in March 2003 (Iraq war), February 2011 (Libyan Civil War) and March 2022 (Russia's invasion of Ukraine)
  - Largest contribution to forecast errors of GSCPI in March 2011, April 2020 and November 2021 (COVID-19) attributed to global supply chain pressure shocks
  - Largest contribution to forecast errors of real oil price inflation in March 2022 attributed to oil price shocks

back

Monetary policy tightens in response to global supply chain pressures

Figure 11: Responses to global supply chain pressure shock



Notes: The figure shows the responses to a one standard deviation global supply chain pressure shock. The solid red line reports the median response. Shaded areas represent the 68% probability bands. The horizontal axis is time, measured in months.

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