Identifying macroeconomic shocks using firm-level data: Material shortages in the German Manufacturing Sector

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Motivation

- Unexpected events trigger questions about (macro)economic consequences
- Identification, quantification, and causal interpretation of (macro) shocks is challenging

  ⟶ Can we identify a (macro) shock using **firm-level information**?

  ⟶ **Bottom-up** approach: Conclusions about aggregate dynamics based on developments in individual units
- Propose construction of external instrument based on firm-level data and apply it to identify a **supply chain shock** and estimate its effect on output and prices in the German manufacturing sector

Construction of the external instrument based on survey data

- Exploit qualitative information on firms' forecast errors (expected vs. realized output & prices), demand situation and production impediments from the ifo business survey to identify firms hit by a supply chain shock
- **Quarterly:** Production impediments

  "Our domestic production is currently constrained by...
  *...insufficient orders/***lack of raw materials or pre-materials***/insufficient technical capacity/ lack of skilled employees/lack of low-skilled employees/financial bottleneck/other"*
- **Monthly:** Firms' expected and realized output, prices and current demand situation

  "**Plans and expectations for the upcoming 3 months:** Our production activity is/prices are expected to...
  ...increase/remain about the same/decrease"

  "**Review: Trends in month t:** Compared to t-1, our prices/production activity...
  ...increased/did not change/decreased"
- Aggregate monthly data x_t^i to quarterly frequency x_T^i:

$$1. \qquad x_t^i = \begin{cases} -1 & \text{if decrease} \\ 0 & \text{if no change} \\ 1 & \text{if increase} \end{cases} \qquad \forall\, x, i.$$

$$2. \qquad x_T^i = \sum_{k=0}^{2} x_{t+k}^i = \begin{cases} \text{decrease} & \text{if } x_T^i < 0 \\ \text{no change} & \text{if } x_T^i = 0 \\ \text{increase} & \text{if } x_T^i > 0 \end{cases} \qquad \forall\, x, i.$$

Intuition:

- Isolate the exogenous share of firms unexpectedly hit by material constraints
- Control group: Account for general forecasting errors and economy-wide shocks

  ⟶ *Assumption:* Absent material constraints, firms do not differ structurally

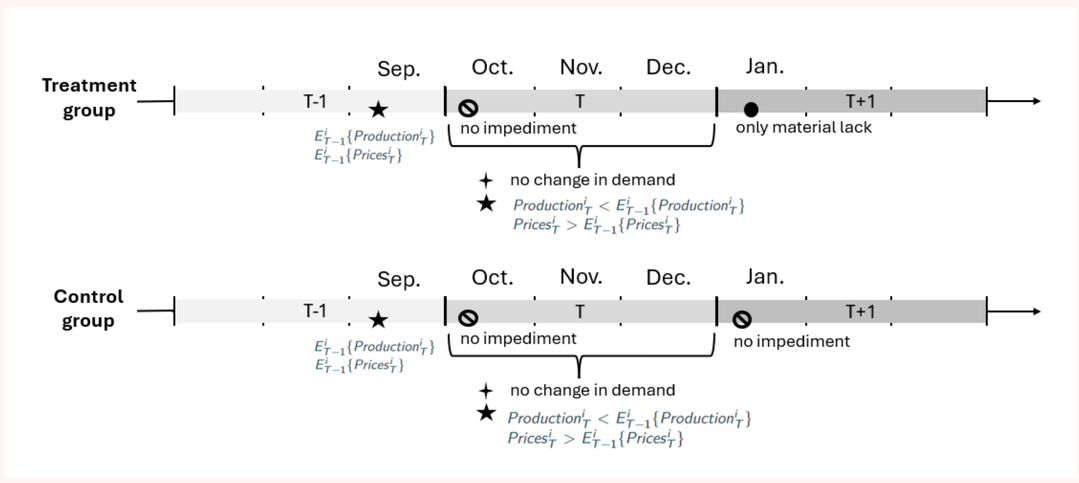

Figure 1. Timing of constraints for identification of a restrictive shock at the firm level

Constructing the shock series

1. Share of firms unexpectedly hit by a supply chain shock for each sub-sector (s)

$$sh^{Restr.}_{t,s,treat.} = \frac{weighted\ \#firms\ sign\ \&\ impediment\ restrictions\ satisfied}{weighted\ \#firms\ impediment\ restrictions\ satisfied} \qquad (1)$$

2. Aggregate sector-level treatment and control group series at manufacturing level

$$sh^{Restr.}_{t,treat.} = \sum_{s=1}^{N} sh_{t,s,treat.} \frac{GVA_s}{GVA}, \qquad sh^{Restr.}_{t,contr.} = \sum_{s=1}^{N} sh_{t,s,contr.} \frac{GVA_s}{GVA} \qquad (2)$$

3. Final *(restrictive)* shock series

$$iv_t^{Restr.} = sh^{Restr.}_{t,treat.} - sh^{Restr.}_{t,contr.} \qquad (3)$$

4. Define an easing shock series, iv_t^{Easing}, using reverse requirements
5. Net effect of easing and restrictive shock series *(average supply chain shock)*

$$iv_t = iv_t^{Restr.} - iv_t^{Easing} \qquad (4)$$

Estimating the effect of a supply chain shock

- Quarterly proxy VAR akin to Mertens and Ravn (2013) and Stock and Watson (2012)
- Variables included:
  - Industrial Production and Producer Prices (log differences)
  - Share of firms reporting (among others) material input constraints (*baseline*)
- Identification via external instrument
- Contrast results to sign restricted identification scheme

Valid identification requires exogeneity and relevance of IV

Relevance

- Supply chain disruptions affecting companies reflected in ifo survey
- Excess forecast error is constructed to reflect material input constraints
- F-statistic on IVs > 10

  [Miranda-Agrippino and Giovanni Ricco (2023), Olea et al (2021)]

Exogeneity

- Shock series *unrelated* to any other shock
- Surprise element: forecast error committed while suffering from sudden material lack → excess share of forecasting error attributable to missing material
- Accounting for *anticipation* effects
- Realisation does not affect individual firm level expectations in previous quarter
- Origin of material lack negligible

Prices more persistently affected than sign restrictions suggest

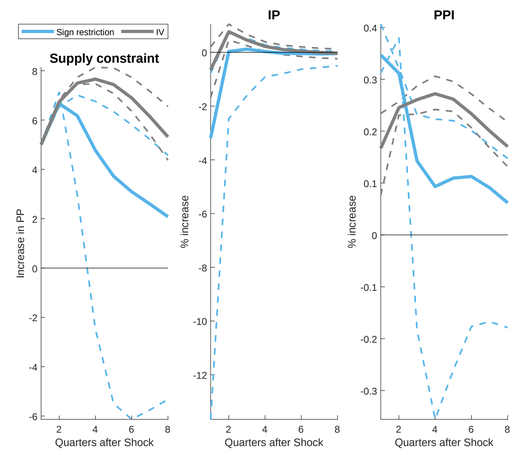

Figure 2. IRFs to a supply chain shock identified via sign restrictions and our instrument.

IRFs normalized to five basis point increase in share of firms reporting material lack and shown along with their 64% confidence bands. Identification achieved using sign restrictions or the instrument constructed as the net shock series (4).

Impact channels differ depending on shock type

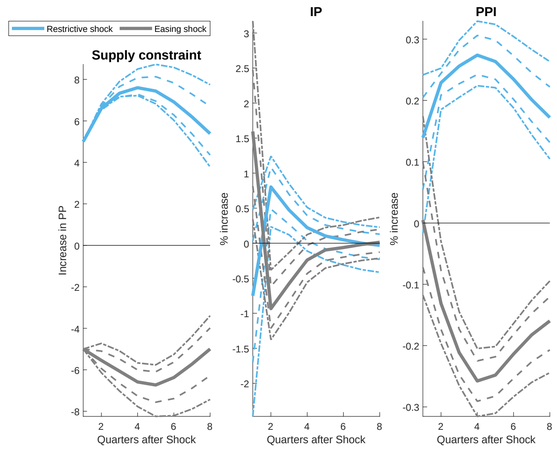

Figure 3. IRFs to restrictive and easing supply chain shocks.

IRFs normalized to a five basis point increase (decrease) in share of firms reporting material lack. Dashed areas show 64%, dashed dotted area 90% confidence bands.

Easing Shock

- Output increases instantaneously
- Prices react with a delay

Restrictive shock:

- Prices increase instantaneously
- Output reacts with a delay

Robustness

IV Construction

- Naive IV specification
- Timing assumption of expectation questions
- Less strict forecast error conditions

Model Specification

- Exclude Covid period
- Alternative lag structure
- Alternative prior & OLS results
- Alternative supply chain measure

Policy implications and way forward

- Supply chain disruptions create inflationary pressure
- Monitoring tensions valuable for (monetary) policy makers
  - Supply chain management
  - Policy response may come with unwanted side effects
  - Particularly for monetary policy and heterogeneous production networks across a monetary union

⟶ Formulate a model to investigate how differences in dynamic responses evolve

⟶ Exploit granularity of data to understand firm-level dynamics

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