

When are supply curves far from the shallow?

Edvin Ahlander (Stockholm University)

Mathias Klein (Sveriges Riksbank)

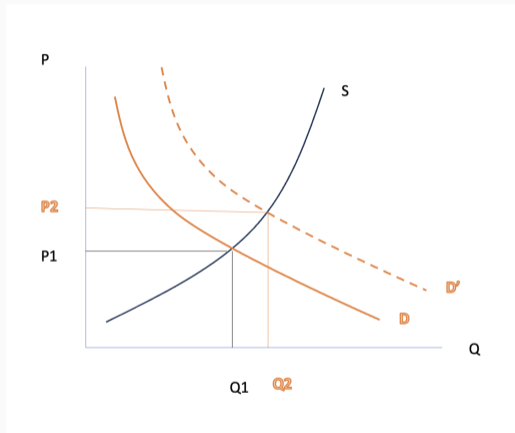
Evi Pappa (Universidad Carlos III de Madrid)

Conference on “Heterogenous Agents in Macroeconomic Models”

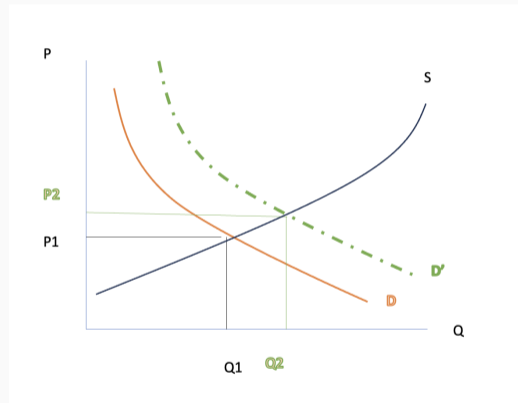
May 2024

The opinions expressed in this presentation are the sole responsibility of the authors and should not be interpreted as reflecting the views of Sveriges Riksbank.

Motivation: the slope of the supply curve



(a) steeper



(b) flatter

- Prices and quantities typically determined simultaneously → challenging to identify supply curves.
- Sensitivity is key for determining the effects of demand-side policies (“flattening of the Phillips Curve”).
- Existing literature uses industry-level data (Boehm and Pandalai-Nayar 2022, Convex Supply Curves).
- Might mask significant heterogeneity across firm distribution.

What we do

- Compile unique monthly firm-level data set on prices and output.
- Covering Swedish industrial firms for more than 20 years (including recent surge in inflation).
- Estimate short and medium run responses of prices and quantities (supply curve) to exogenous shocks.
- Large cross-sectional variation allows to investigate important non-linearities.

What we find

- On average, upward sloping supply curve.
- Exogenous increase in firm level sales by 1 percent increases prices by 0.3 percent.
- Important non-linearities:
 - **Aggregate level:** steeper in times of high inflation and low financial uncertainty.
 - **Individual level:** flatter for firms with low market power and exporting firms.
- Implications:
 - 1 Responses to shocks are state dependent.
 - 2 Nonlinear Phillips curve.

- **Supply curves at the industry level:** Boehm and Pandalai-Nayar (AER, 2022), Shea (QJE, 1993).
We: Firm-level data, allows to investigate further non-linearities.
- **Cross-sectional data to estimate slope of the Phillips curve:** Hazel et al. (QJE, 2022), Gagliardone et al. (WP, 2023).
We: Granular data to provide new evidence on the slope of supply curves.
- **Non-linearities in macro:** Baqaee and Farhi (Econometrica, 2019), Bigio and La'O (QJE, 2020), Michailat (AEJM, 2014), Harding et al. (JME, 2023)...
We: Aggregate and individual determinants of the slope of supply curves.

- **Price data**

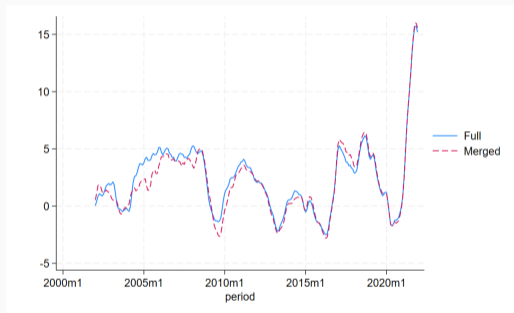
- Micro price data underlying official producer price index (1992M1-2022M9).
- Product-level data, mainly manufacturing sector, several multi-product firms.
- Domestic prices, import prices, export prices.
- Roughly 1.75 million product-month observations.

- **Output data**

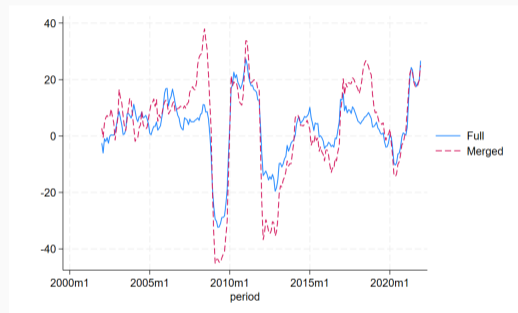
- Micro data underlying official industrial production index (1998M1-2022M9).
- Firm-level sales, manufacturing sector, deflated with aggregate index.
- Total sales = sales in domestic market + sales in export market.
- Roughly 550,000 firm-month observations.

- Construct firm-level price index using (annual) data on delivered quantities (IVP).
- Can be merged with other (annual) administrative dataset (UC) to get information on balance sheet items and real variables (assets, debt, employment, wage bill,...).

Aggregate inflation and output



(a) PPI ($\rho = 0.98$)



(b) IPI ($\rho = 0.89$)

Empirical approach

- Local projections at the firm-level i :

$$\sum_{j=0}^h \pi_{i,t+j} = \alpha_{i,h} + \alpha_{m,h} + P_h \sum_{j=0}^h \Delta sales_{i,t+j} + \gamma_h \sum_{p=1}^6 X_{i,t-p} + u_{i,t,h}.$$

- $X_{i,t}$: $\pi_{i,t}$ and $\Delta sales_{i,t}$. 3-months MA because sales are very volatile.
- Focus on *domestic* sales and prices, $\approx 50,000$ firm-month observations (2001M1-2021M12).
- State-dependencies:

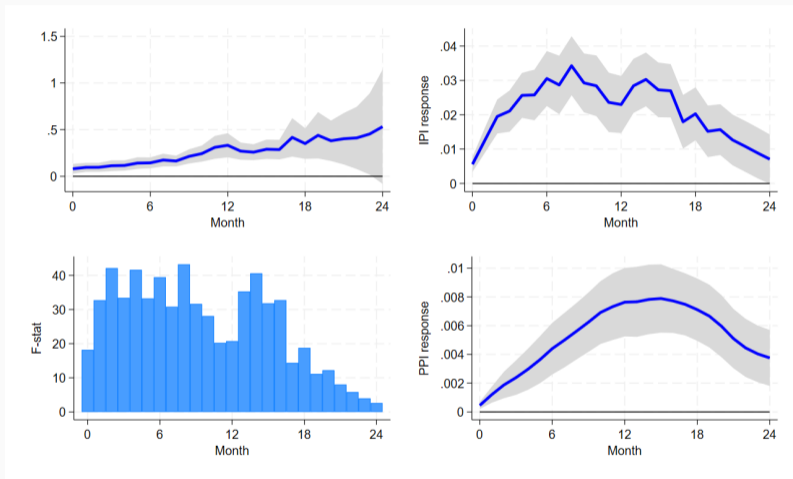
$$\begin{aligned} \sum_{j=0}^h \pi_{i,t+j} = & I_{i,t-1} \left[P_h^A \sum_{j=0}^h \Delta sales_{i,t+j} + \gamma_h^A \sum_{p=1}^6 X_{i,t-p} \right] \\ & + (1 - I_{i,t-1}) \left[P_h^B \sum_{j=0}^h \Delta sales_{i,t+j} + \gamma_h^B \sum_{p=1}^6 X_{i,t-p} \right] + \alpha_{i,h} + \alpha_{m,h} + u_{i,t,h}. \end{aligned}$$

- Aggregate: $I_{i,t} = I_t$, individual: $I_{i,t} = I_{i,t}$

Identification

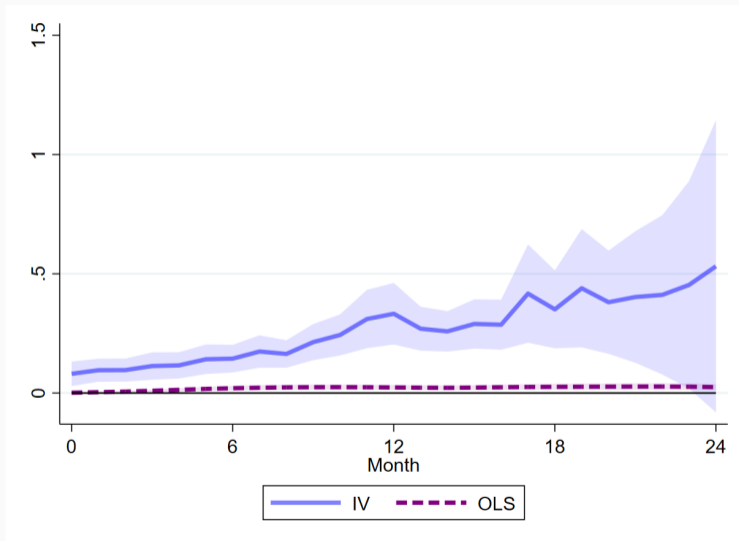
- Estimating by OLS might be biased (confounding supply shocks).
- We rely on an external instrument that drives world industrial production:
 - Baumeister Hamilton (2019, AER): shock to global demand for industrial commodities.
 - Bayesian oil market VAR: $Y^{Oil} \uparrow$, $Y^{World} \uparrow$, $P^{Oil} \uparrow$.
- Increase in world industrial production raises firms' export sales.
- Via domestic input-output linkages, this increases demand for *domestic* goods and leads to higher *domestic* prices.
- Could still include supply components but:
 - 1 Results robust to controlling for firm level import prices.
 - 2 Similar results when relying on alternative instruments (Swedish and ECB monetary policy shocks).

Baseline results

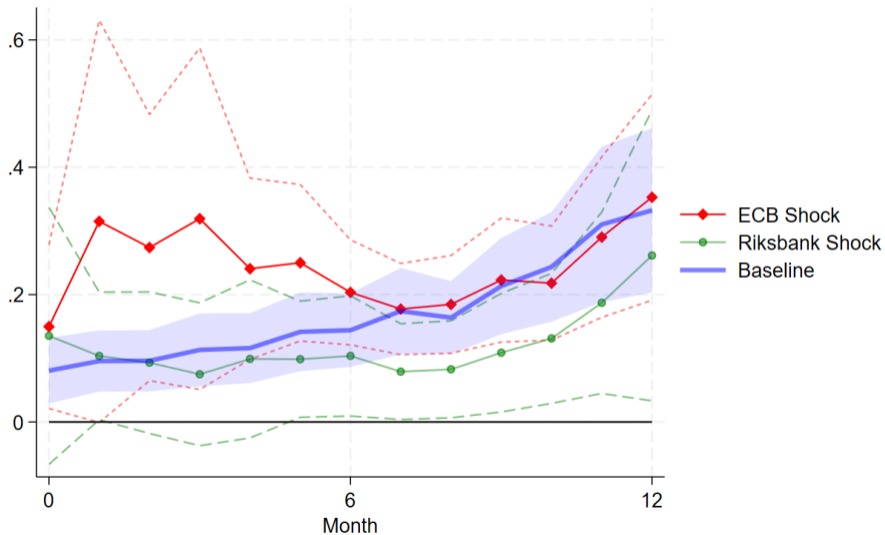


- Boehm and Pandalai-Nayar (2022, AER): 0.24.

Identification is key

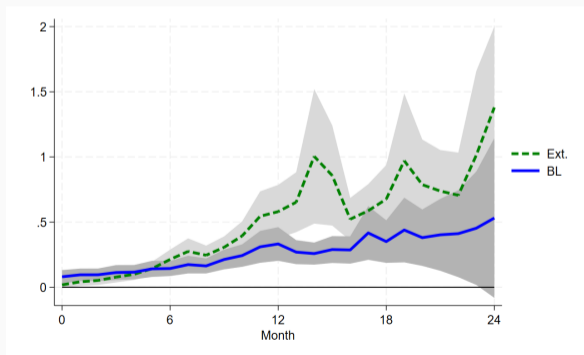


Robustness, Swedish and ECB MPshocks

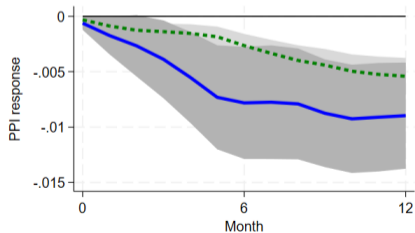
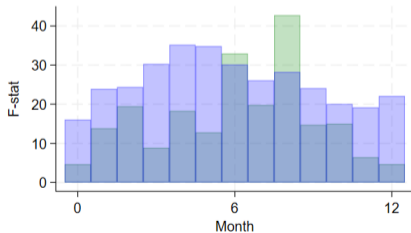
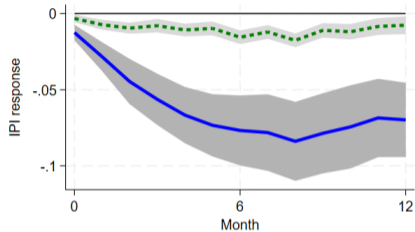
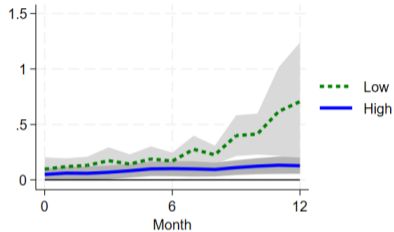


Including recent surge in inflation

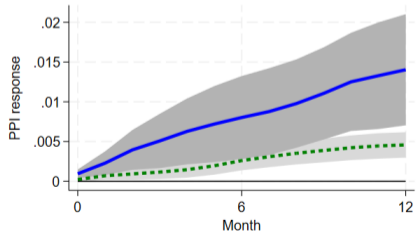
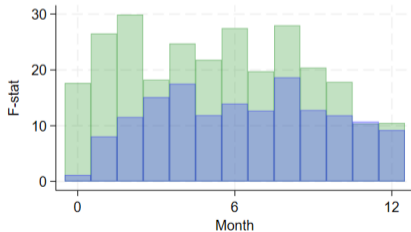
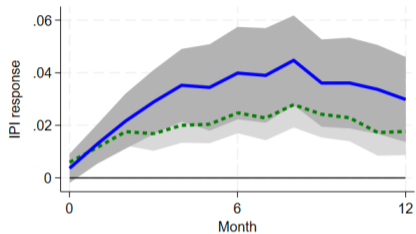
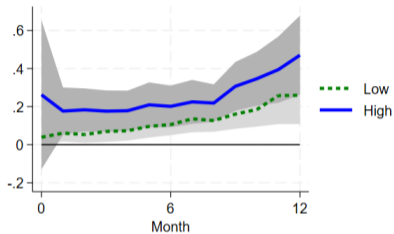
- We stop in December 2021, because products weights not (yet) available for 2022.
- But price and sales data up until September 2022. Assume same product weights for 2022 as for 2021.



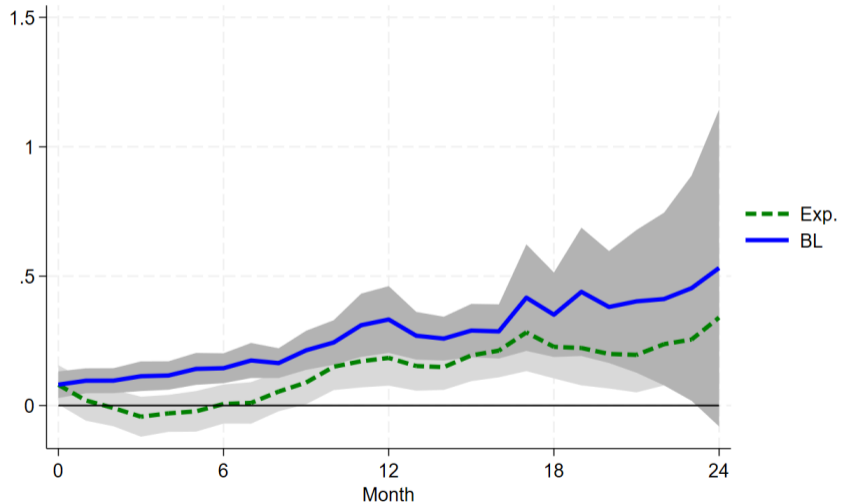
State-dependency, uncertainty (VIX Volatility)



State-dependency, market power (market share)



State-dependency, export PC



Conclusion

- Unique monthly firm-level data set on output and prices.
- Estimating short and medium run supply curves by IV-local projections.
- Average elasticity around 0.3.
- Important **aggregate determinants**: level of inflation, financial volatility.
- Important **individual determinants**: market power, exporting firms (more in the paper: productivity, sales volatility, leverage, cost structure,...).
- Non-linearities matter for designing demand-side policies.

Thank you!

Merging sales and price data

- Problem: sales data at firm-level, price data at product-level.
- How to construct price-index at the firm-level?
- IVP dataset: annual product-level information on delivered quantities and prices to get product-weights at the firm level.
- Still some discrepancy between firm-level sales and prices, because we might not observe all product prices in the PPI.
- Keep only those firms for which we observe at least 50% of their total production value in the PPI.

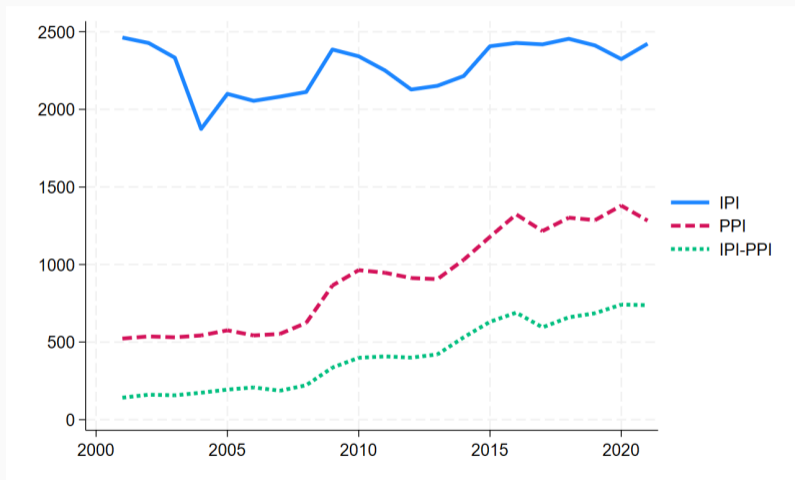
Summary statistics, balance sheet items

	IPI	PPI	IPI-PPI	IPI	PPI	IPI-PPI
	Assets			Sales		
Mean	18.09	19.13	19.57	18.58	19.59	20.01
Standard deviation	1.85	1.69	1.58	1.73	1.56	1.43
25th percentile	16.84	17.98	18.52	17.38	18.55	19.05
Median	17.99	18.95	19.40	18.54	19.44	19.87
75th percentile	19.21	20.12	20.45	19.66	20.53	20.82
	Employment			Productivity		
Mean	4.06	4.76	5.10	14.56	14.85	14.92
Standard deviation	1.38	1.29	1.19	0.72	0.73	0.72
25th percentile	3.09	3.85	4.26	14.10	14.39	14.48
Median	3.99	4.62	5.00	14.50	14.77	14.85
75th percentile	4.93	5.56	5.87	14.97	15.24	15.31

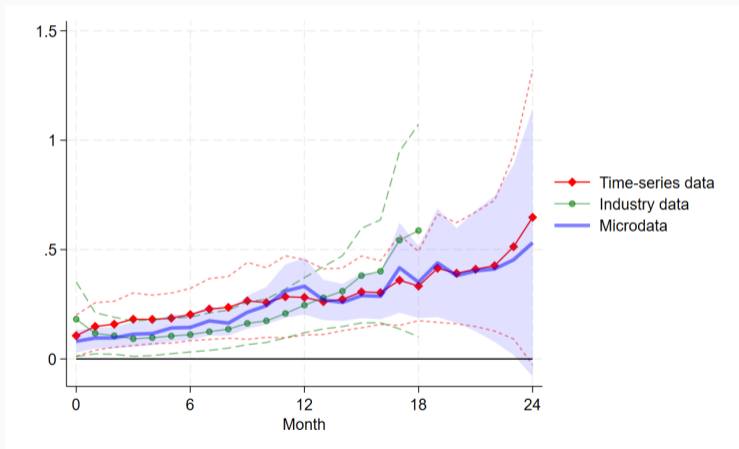
Summary statistics, prices and sales data

	PPI/IVP	IPI-PPI	PPI/IVP	IPI-PPI	PPI/IVP	IPI-PPI
	Price-change frequency		Market Share		Number of products	
Mean	4.84	5.19	0.16	0.23	3.47	3.67
Standard deviation	4.65	4.71	0.24	0.28	5.68	5.82
25th percentile	1.00	1.00	0.01	0.03	1.00	1.00
Median	3.00	3.00	0.04	0.10	2.00	2.00
75th percentile	10.00	11.00	0.18	0.34	3.00	4.00

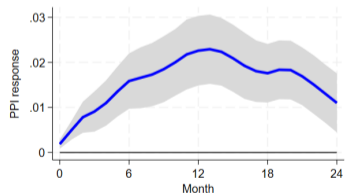
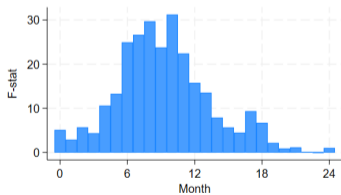
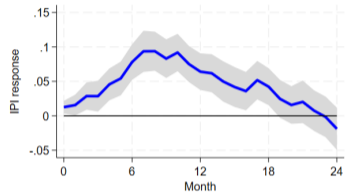
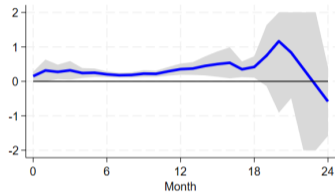
Total number of firms



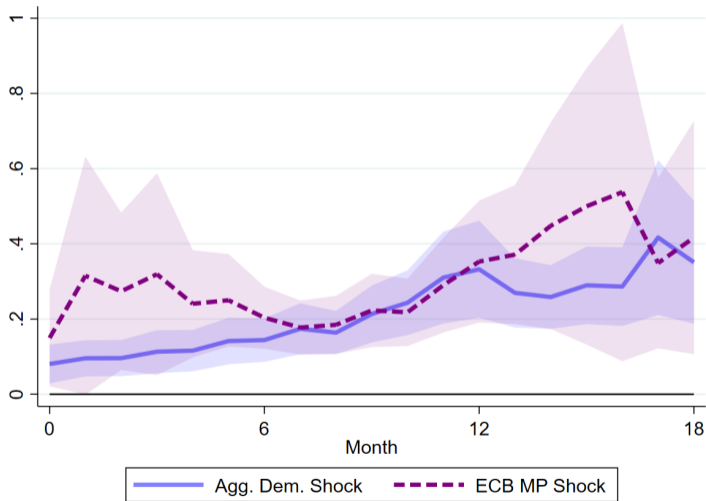
Micro versus Macro Data



Robustness, ECB MPshock



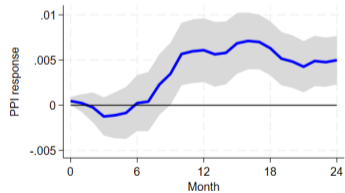
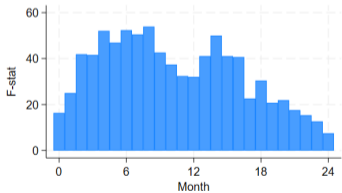
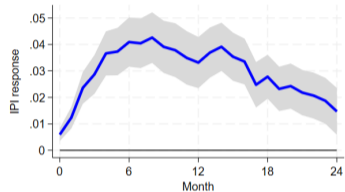
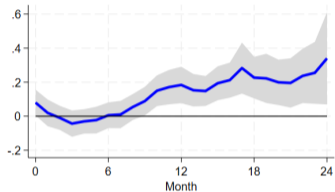
Robustness, ECB MPshock



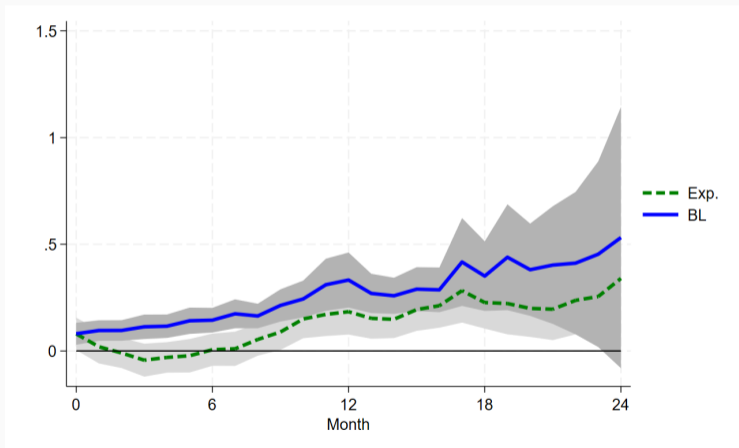
Further extensions, export PC

- So far, analysis based on domestic prices and sales.
- Have also information on sales and prices of exported goods.
- However, we do not know the exact weight of each product item in total exported sales for a firm. Needed to construct firm price index.
- We assume that the weights are similar to the domestic price analysis.

Further extensions, export PC



Further extensions, export PC



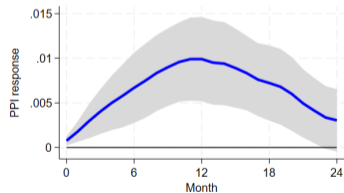
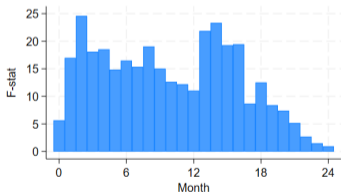
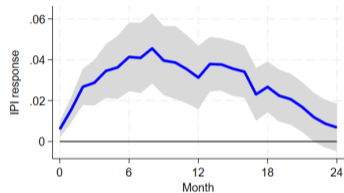
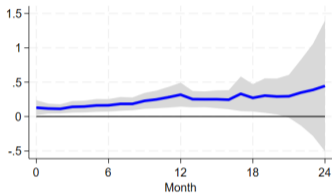
Exclusion restriction

- Global economic activity shock might also affect costs, thereby influencing supply.
- We have information on prices of imported goods (part of PPI database).
- Caveats:
 - 1 No information on quantities (take simple average)
 - 2 Only available for part of the sample (less than 40%).

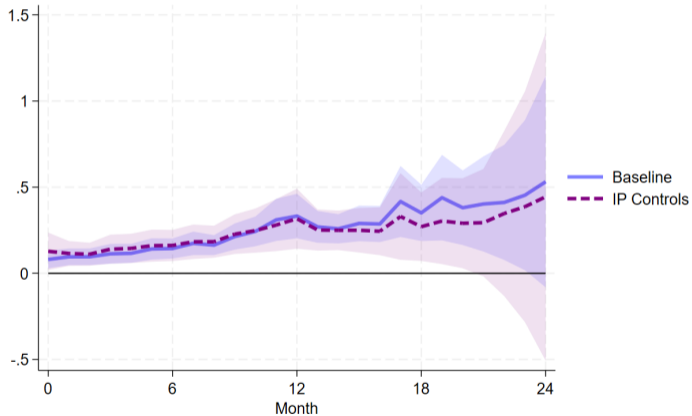
$$\sum_{j=0}^h \pi_{i,t+j}^{Domestic} = \alpha_{i,h} + \alpha_{m,h} + \beta_h \sum_{j=0}^h \Delta sales_{i,t+j} + \gamma_h \sum_{p=1}^6 X_{i,t-p} + \lambda_h \sum_{l=0}^6 \pi_{i,t-l}^{Import} + u_{i,t,h}.$$

- Individual lagged controls, $X_{i,t}$: $\pi_{i,t}^{Domestic}$ and $\Delta sales_{i,t}$.

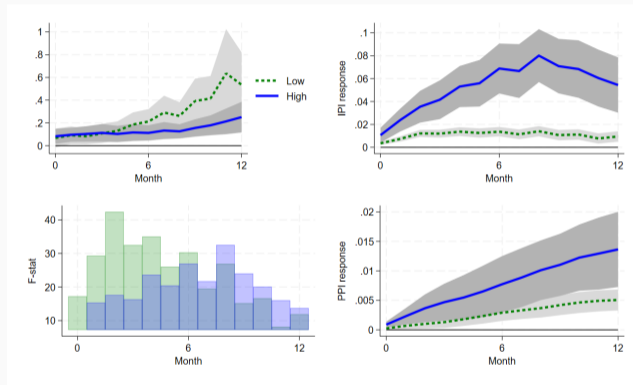
Controlling for import prices



Controlling for import prices



State-dependency, uncertainty (cross-sectional volatility in firm sales)



- Classify **firms** based on standard deviation of sales growth across all months.

Capacity utilization, Boehm/Pandalai-Nayar (2022)

