What Can Stockouts Tell Us About Inflation? Evidence from Online Micro Data

Alberto Cavallo
Harvard Business School

Oleksiy Kryvtsov
Bank of Canada

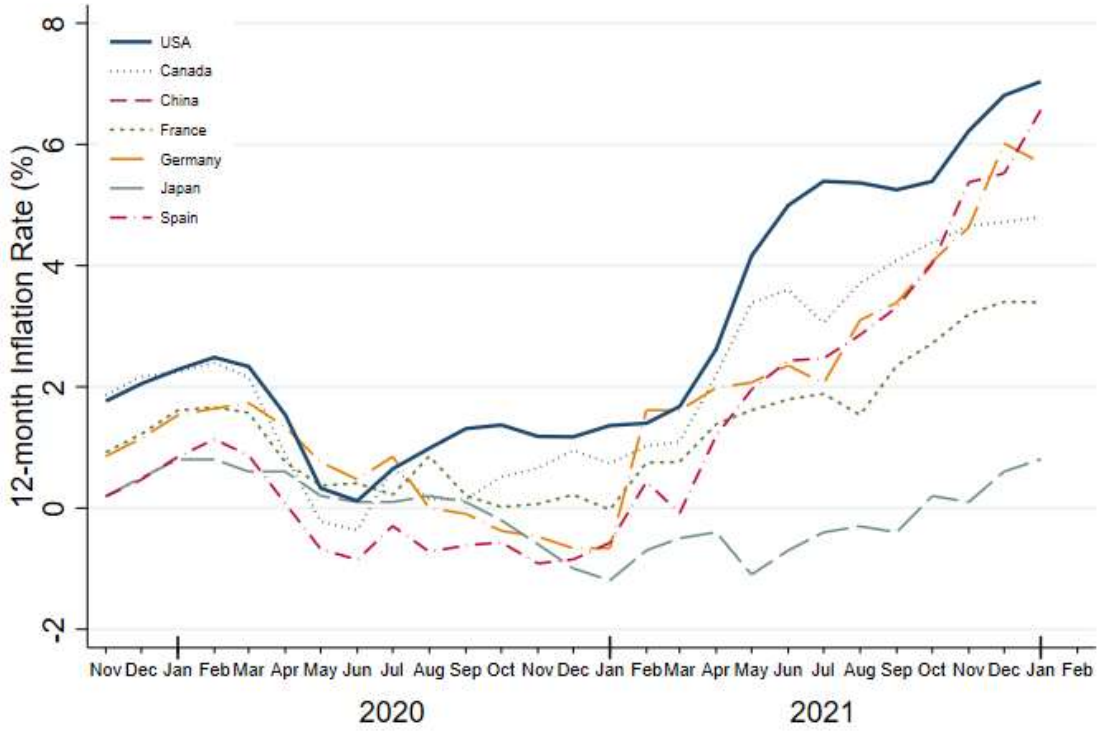
ISOM , Athens
June 20-21, 2022

The views expressed here are ours, and they do not necessarily reflect the views of the Bank of Canada

Motivation

- Inflation during Covid: small initial decline, quickly rebounded, reached decades high by end 2021

CPI Inflation Rates



- Did supply disruptions play an important role in these price dynamics?

Paper summary

- Create two high-frequency measures of consumer product shortages in 7 countries
  - temporary stockouts, discontinued products
- Document a multi-fold rise in shortages in nearly all sectors early in the pandemic
  - Over time, the composition of shortages evolved from many temporary stockouts to mostly discontinued products, concentrated in fewer sectors
- Are shortages associated with inflation?
- Are the inflation effects stronger for imported goods?
- What do observed prices and shortages imply about the cost to replenish inventories?

Prices and stockouts micro data

- We use daily product data collected by PriceStats (The Billion Prices Project)
- Data scraped from websites of large multi-channel retailers that sell mostly offline

<html>
<product> Leche Condensada </product>
<brand> Nestlé </brand>
<td price> $1.199 Uni </td>

	ID	ID2	PRODUCT	BRAND	SIZE	BULK PRICE	PRICE
1	3429	266235-ST	Leche Condensada	Leche Sur	Lata 395 grs.	xKilo:$1.744	689
2	3422	266231-ST	Leche Condensada	Nestlé	Descremada, Lata 395 grs.	xKilo:$2.023	799
3	995	619436-ST	Leche Condensada	Nestlé	Envase flexible 350 grs.	xKilo:$2.569	899
4	3804	399781-ST	Leche Condensada	Nestlé	Lata 397 grs.	xKilo:$1.761	699
5	11676	668674-ST	Leche Condensada	Nestlé	Pack 3 unidades, Lata 200 grs. c/u	xKilo:$1.998	1.199

Measuring shortages in retail (sector *j*, country *c,* date *t*)

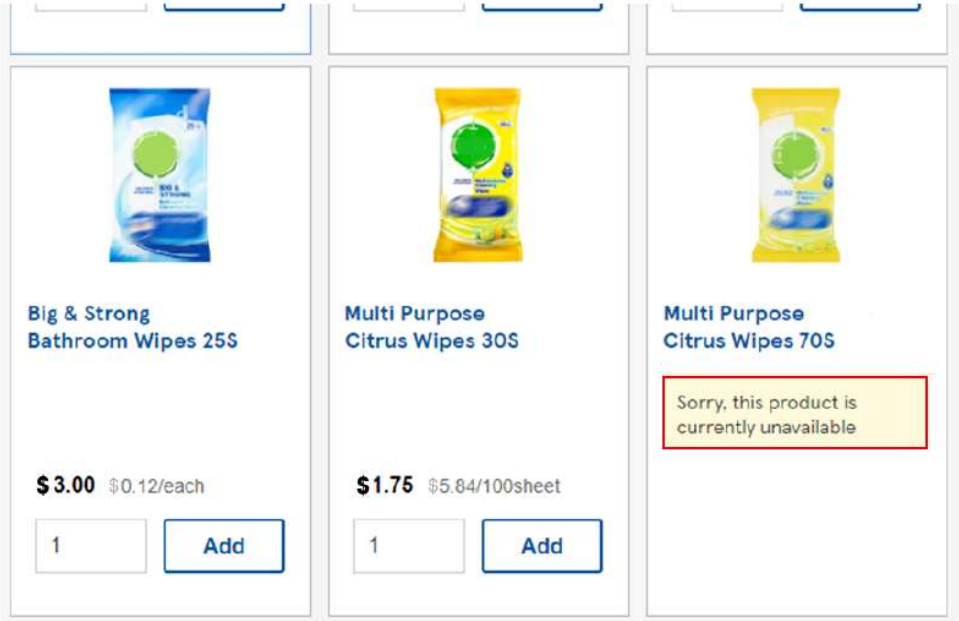


Figure 1: Identifying Stockouts on a Retailer's Website

- Temporary Stockouts $(TOOS_{jc,t}) = \frac{\#\ out\ of\ stock_{jc,t}}{\#\ total\ products_{jc,t}}$

Measuring shortages in retail (sector *j*, country *c*, date *t*)

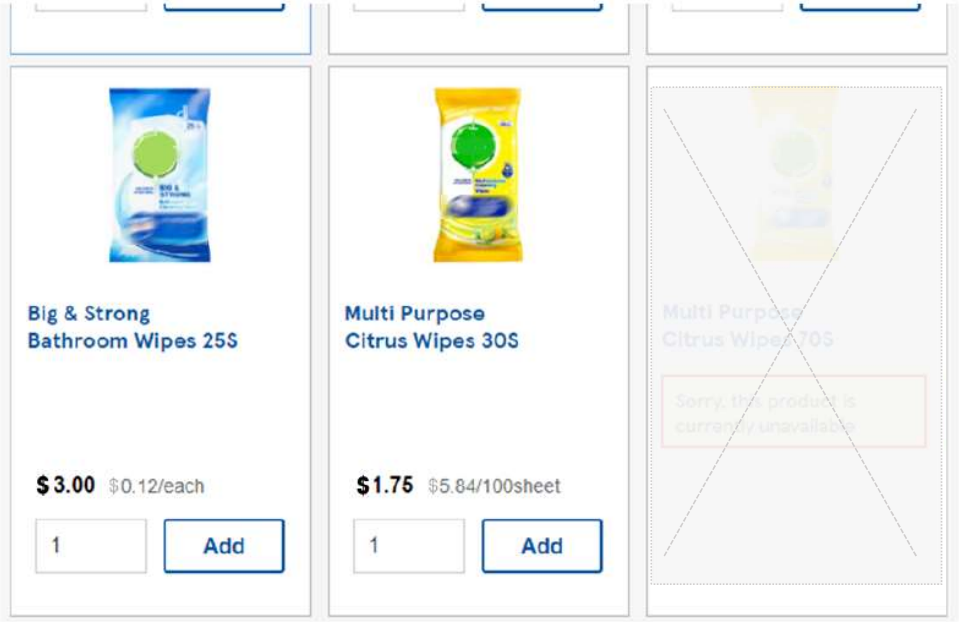


Figure 1: Identifying Stockouts on a Retailer's Website

- Temporary Stockouts $(TOOS_{jc,t}) = \frac{\#\ out\ of\ stock_{jc,t}}{\#\ total\ products_{jc,t}}$
- Permanent Stockouts $(POOS_{jc,t}) = 1 - \frac{\#\ total\ products_{jc,t}}{\#\ total\ products_{jc,Jan-2020}}$

Measuring shortages in retail (sector *j*, country *c*, date *t*)

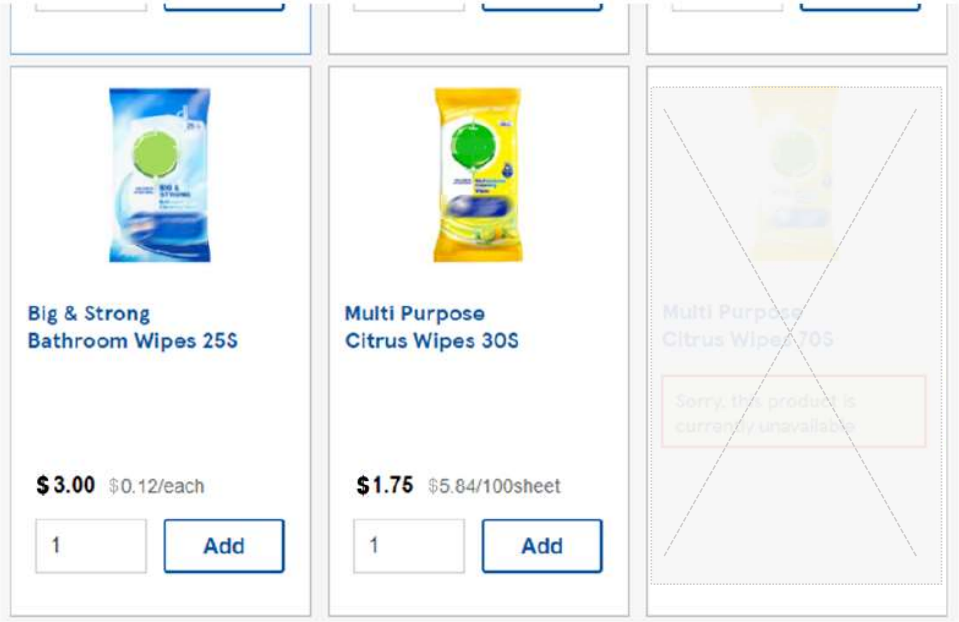


Figure 1: Identifying Stockouts on a Retailer's Website

- Temporary Stockouts $(TOOS_{jc,t}) = \frac{\#\ out\ of\ stock_{jc,t}}{\#\ total\ products_{jc,t}}$
- Permanent Stockouts $(POOS_{jc,t}) = 1 - \frac{\#\ total\ products_{jc,t}}{\#\ total\ products_{jc,Jan-2020}}$
- All Stockouts = $1 - \frac{\#\ total\ products_{jc,t} - \#\ out\ of\ stock_{jc,t}}{\#\ total\ products_{jc,Jan-2020}}$

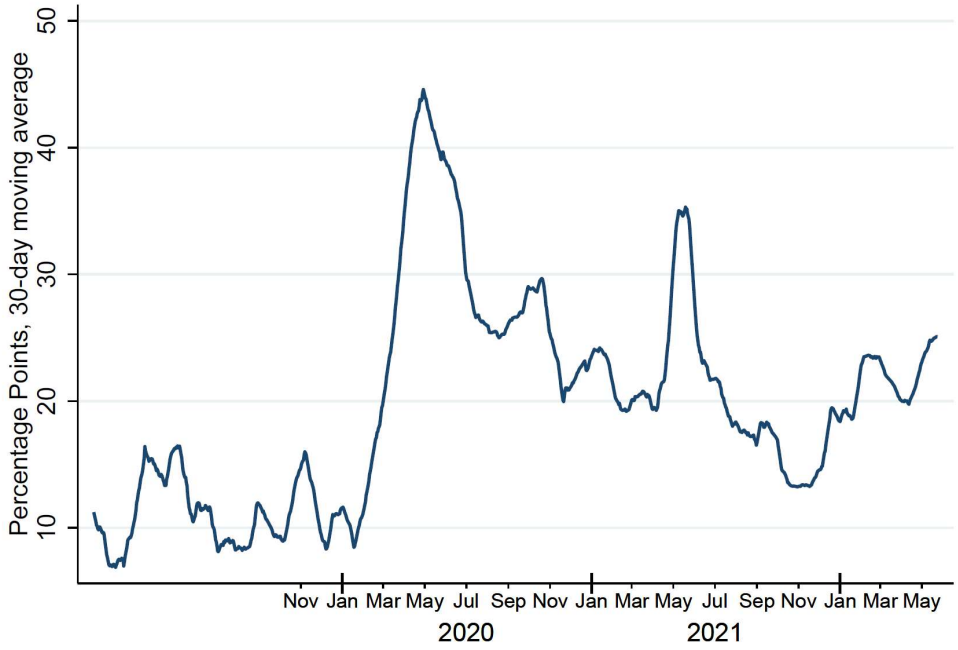
Micro data in this paper

- We focus on 70 retailers in 7 countries that show "out of stock" information

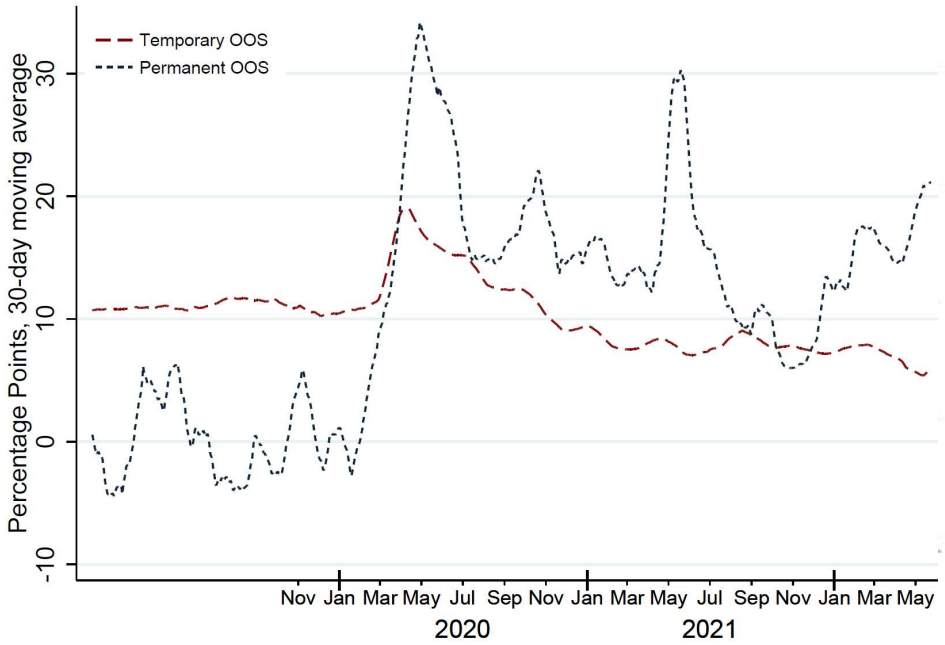
	Products	Retailers	Coverage of All CPI Weights, (%)	Coverage of Goods CPI Weights, (%)
Canada	194,151	11	27	80
China	49,685	3	38	76
France	372,962	11	32	63
Germany	297,320	13	27	52
Japan	95,313	7	30	68
Spain	171,400	8	31	56
USA	777,554	17	21	62
All	1,958,385	70	29	65

- Sectors: Food & Beverages, Furnishings & Household, Health, Electronics, Other goods
  - Not included: Cars, Gasoline, Alcohol & Tobacco, Apparel
- We start at the disaggregated COICOP 3-digit level, then build aggregate series using official CPI weights

Stockout dynamics in the United States

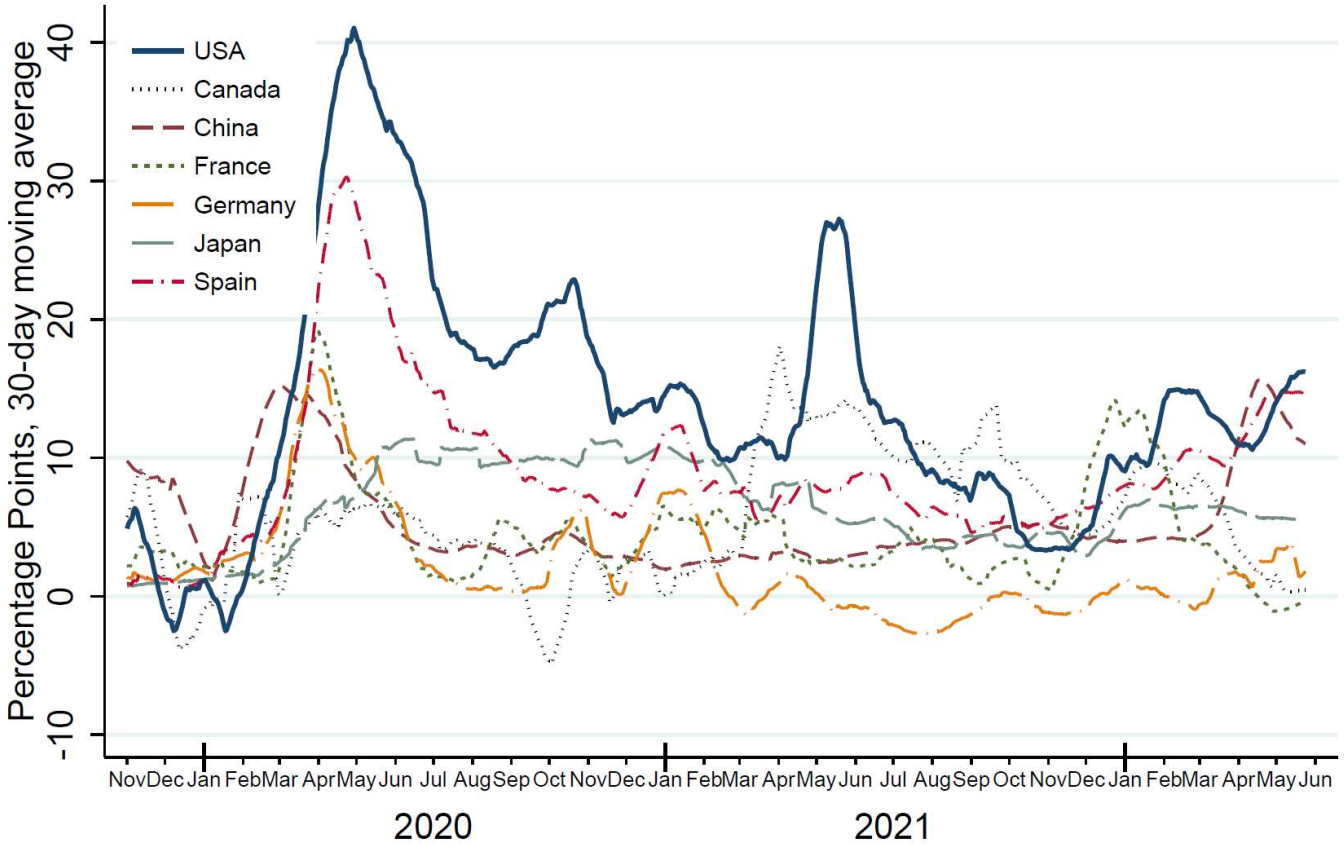


(a) All Stockouts

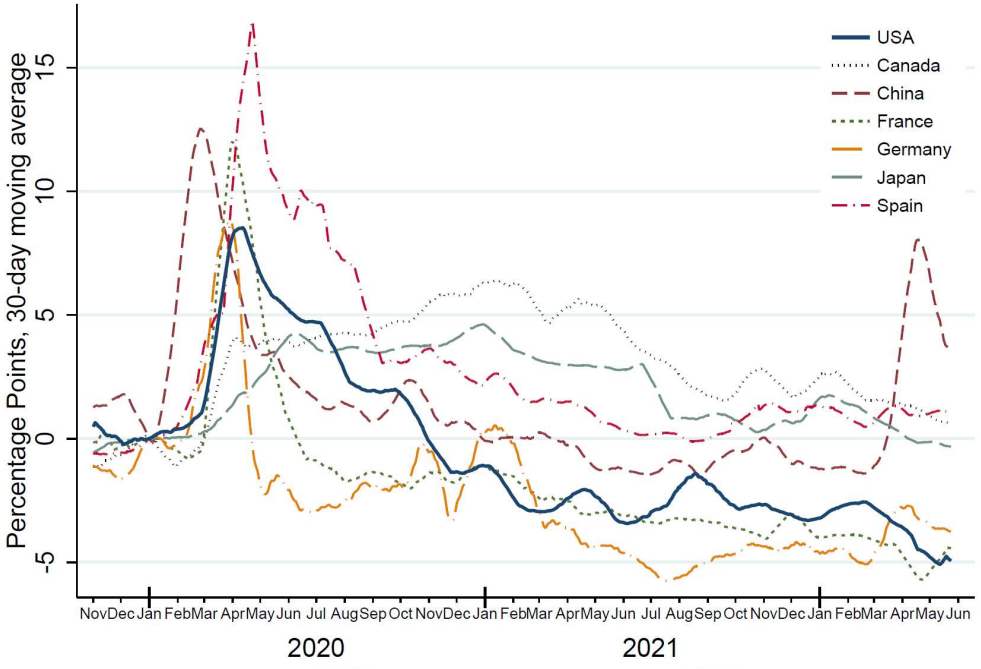


(b) Temporary and Permanent Stockouts

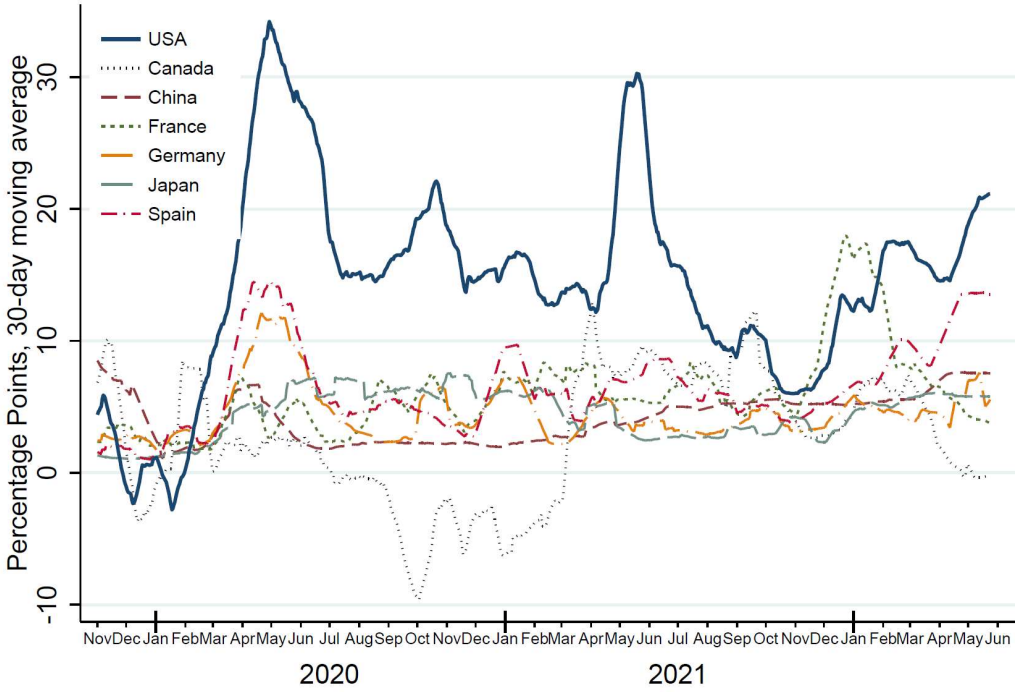
Stockout dynamics in 7 countries



Stockout dynamics in 7 countries

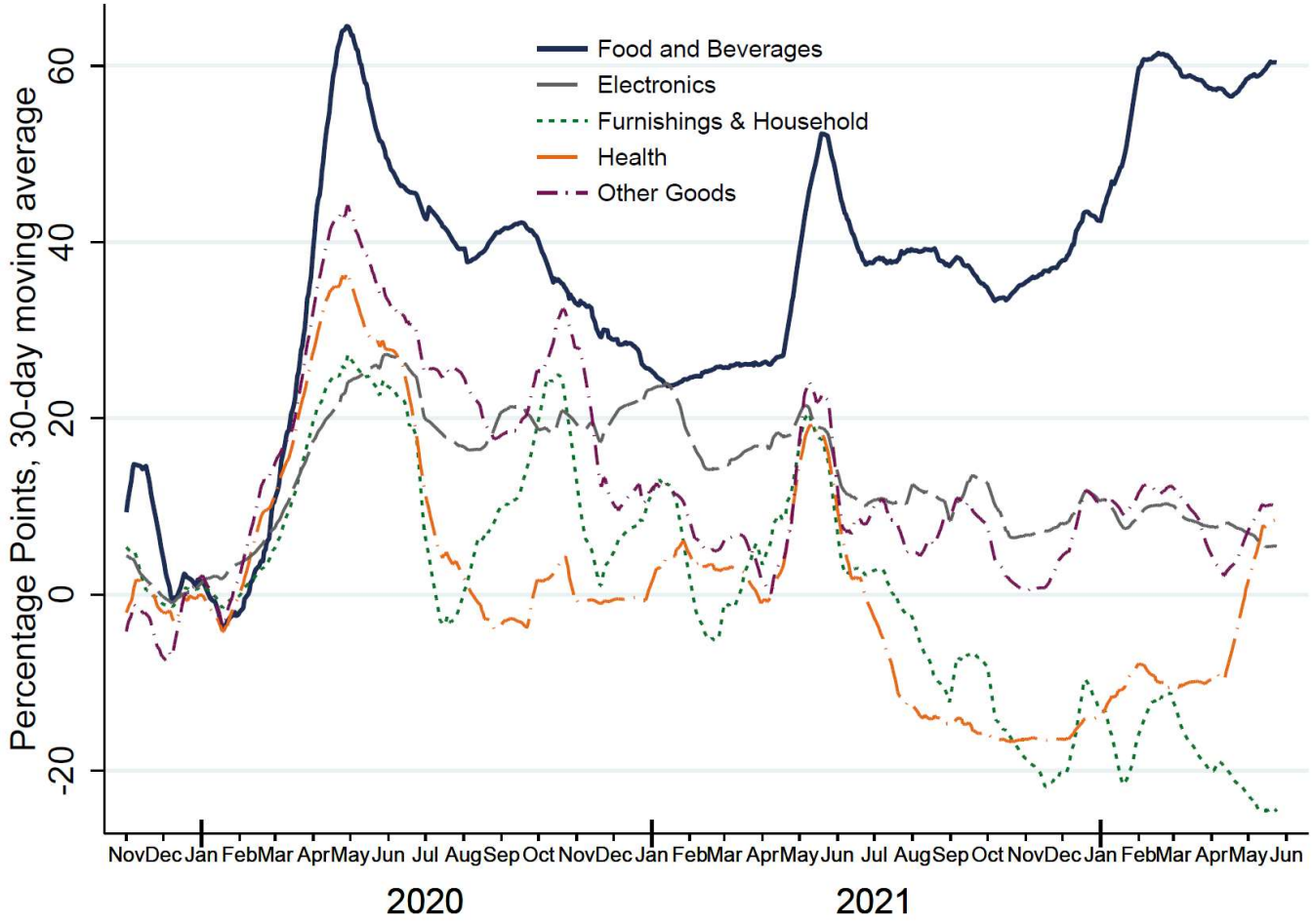


(a) Temporary Stockouts

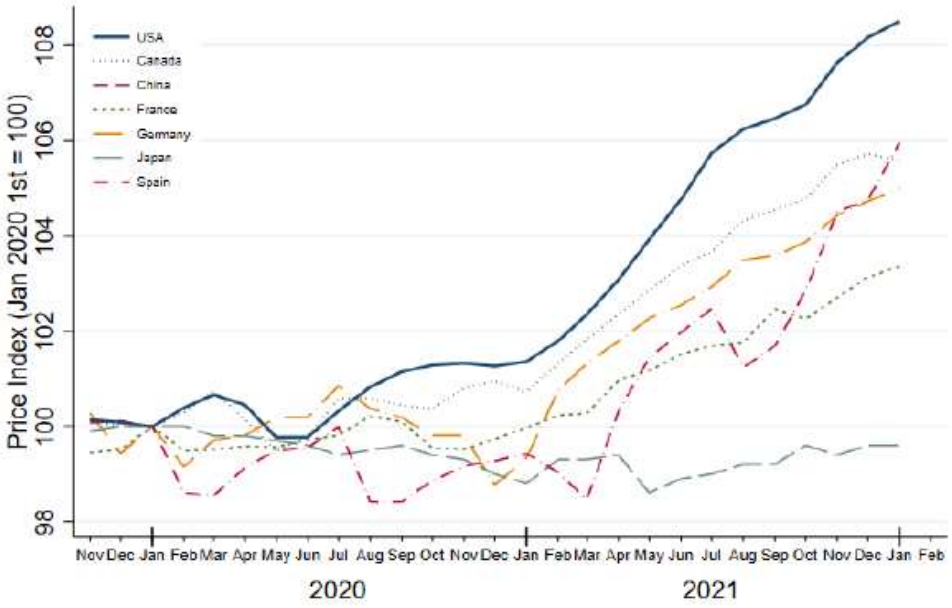


(b) Permanent Stockouts

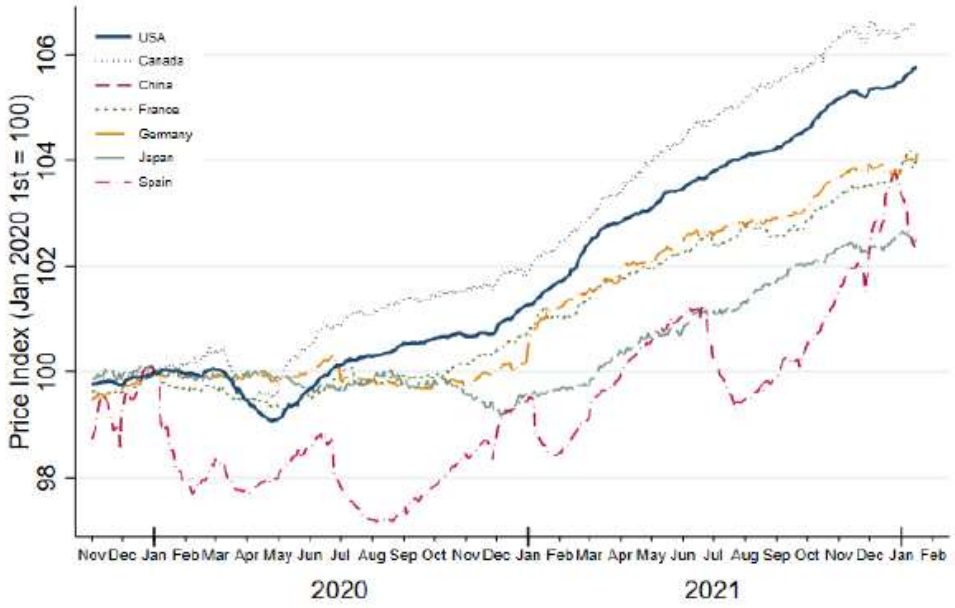
In the United States, stockouts are more persistent in Food & Beverages



Are product shortages associated with inflation?



(a) Official CPIs



(b) Online Price Indices

Estimation of responses to stockouts shocks, 235 sectors in 7 countries

- Estimate the response of inflation to an exogenous stockout disturbance at the 3-digit level

- Stockout shock: residual of an AR(1) process for the weekly stockout rate in sector *j* country *c*

$$OOS_{cj,t} = c_{cj} + \beta_{cj} OOS_{cj,t-1} + \epsilon_{cj,t}$$

- Estimate impulse responses to the stockout shock using linear projections (Jordà, 2005):

$$X_{cj,t+h} - X_{cj,t-1} = c^{(h)} + \sum_{l=0}^{L} \beta_l^{(h)} \epsilon_{cj,t-l} + \sum_{n=1}^{N} \delta_n^{(h)} X_{cj,t-n} + D_{cj} + error_{cj,t}^{(h)}$$

$X_{cj,t}$ is monthly inflation rate or stockout rate (*TOOS* or *POOS*)

D_{cj} are sector-country fixed effects

$\widehat{\beta}_l^{(h)}$ provide the estimated impulse response at horizon *h*

Result 1: Shortages are associated with rising sector prices within 2 months

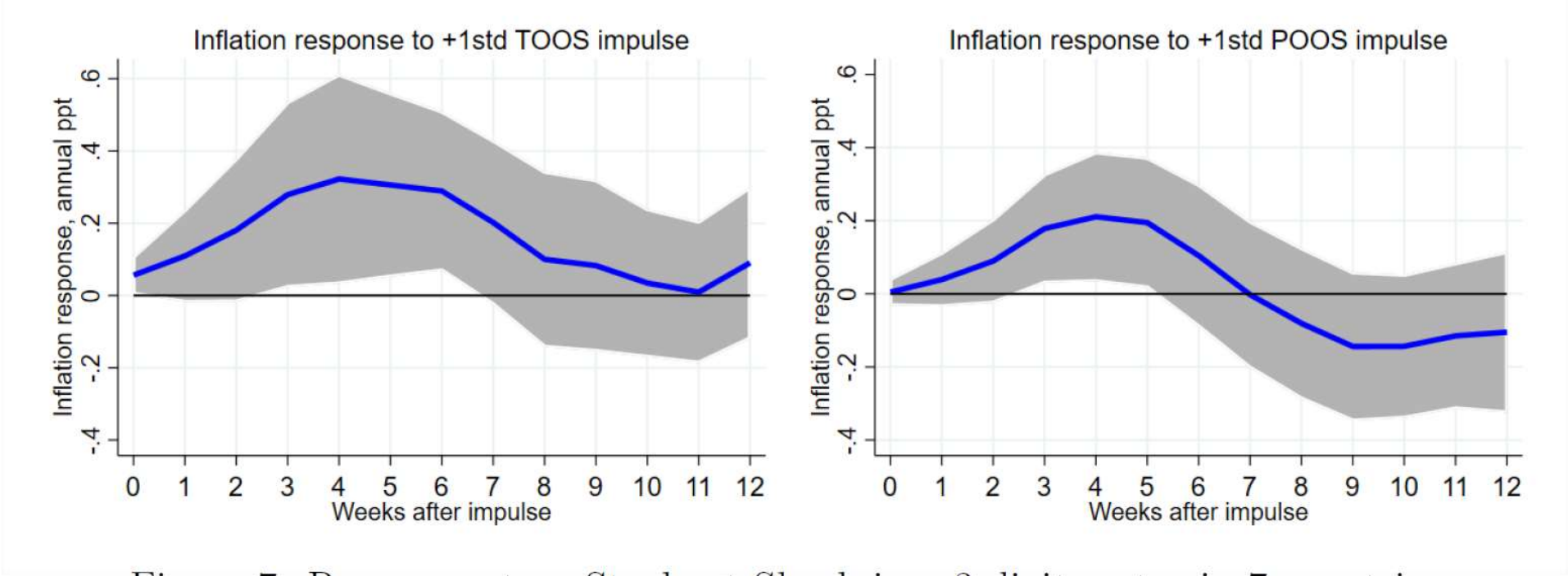
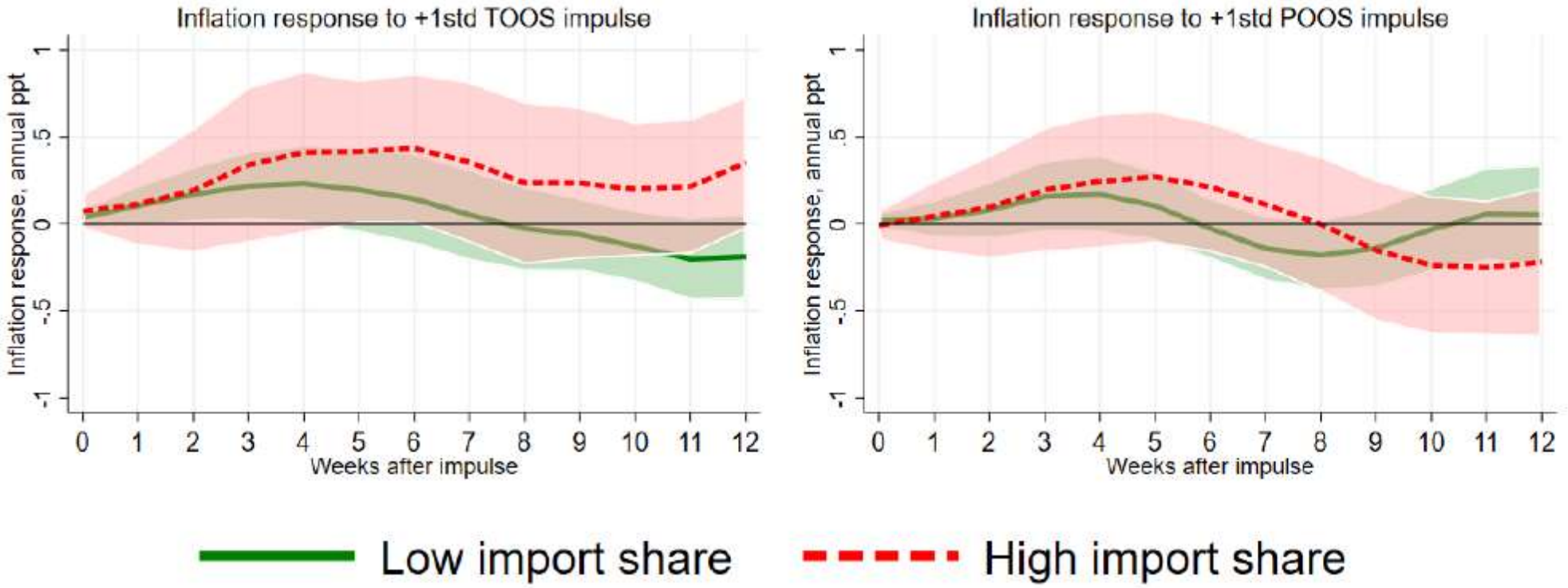


Figure 7: Responses to a Stockout Shock in a 3-digit sector in 7 countries

- Doubling stockouts from 10% to 20% increases sector inflation by 1.6 ppt (annualized rate)

Result 2a: Inflation response is larger & longer in import intensive sectors

- Split 235 sectors (7 countries) into groups below/above weighted median import share (0.24)
  - Low shares: unprocessed food, plants, printed material
  - High shares: video/audio equipment, furniture, jewelry and watches

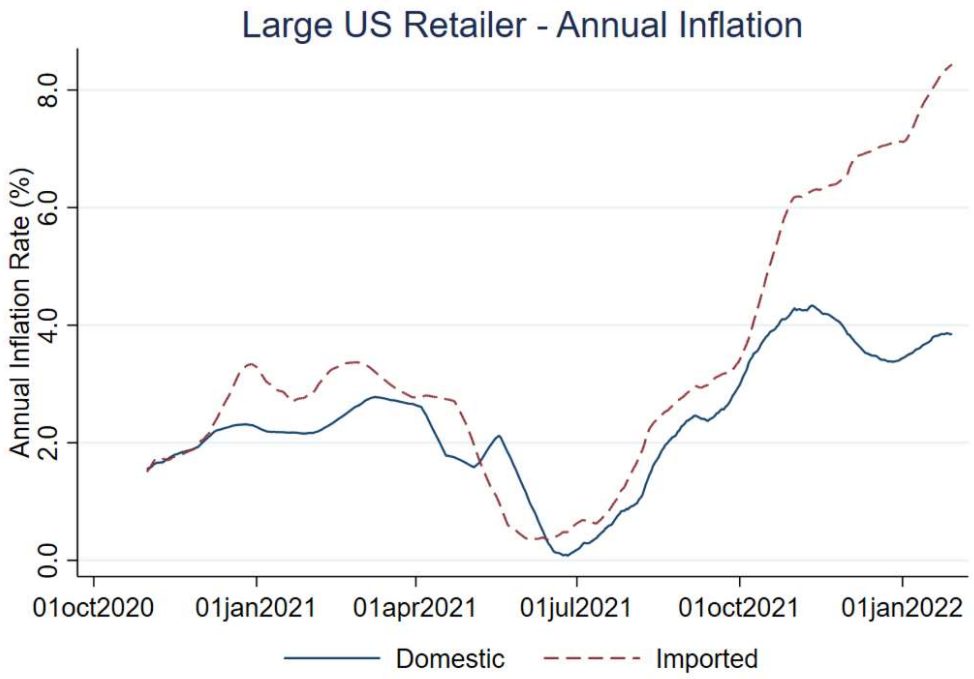


Micro evidence from a large U.S. retailer

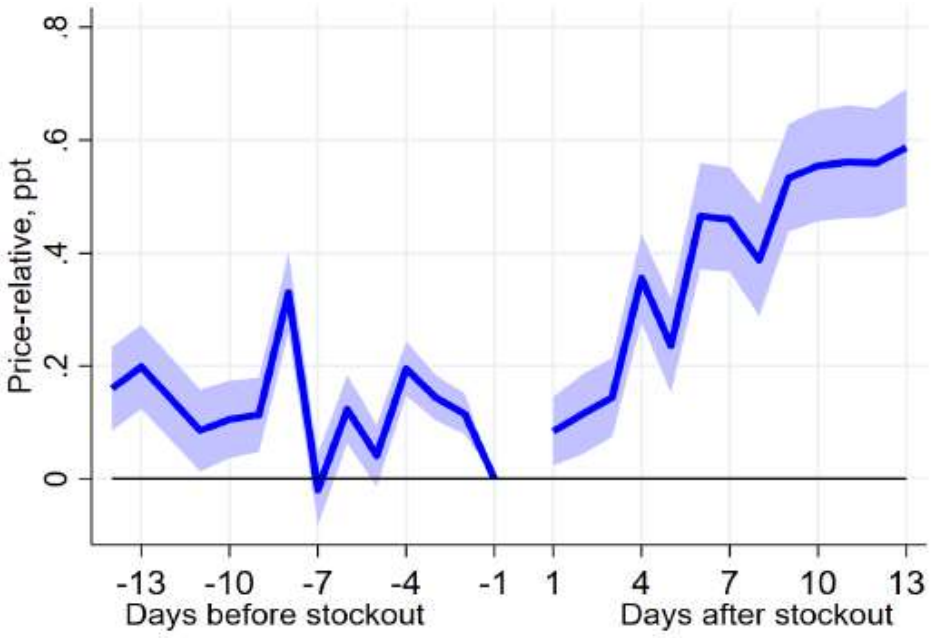
- Country-of-origin information for each good provided by the retailer (from Cavallo, Gopinath, Neiman, Tang (2021))
- Imported goods had more frequent stockouts, longer stockouts, more inflation

	U.S. Retailer
Number of products	16,953
imported	12,275
domestic	4,678
Fraction of stockouts, %	5.3
imported	5.2
domestic	4.0
Stockout duration, days	27.4
imported	26.0
domestic	18.5
Product inflation, ann %	2.8
imported	3.3
domestic	2.3

Table 2: Summary statistics for a large U.S. retailer.



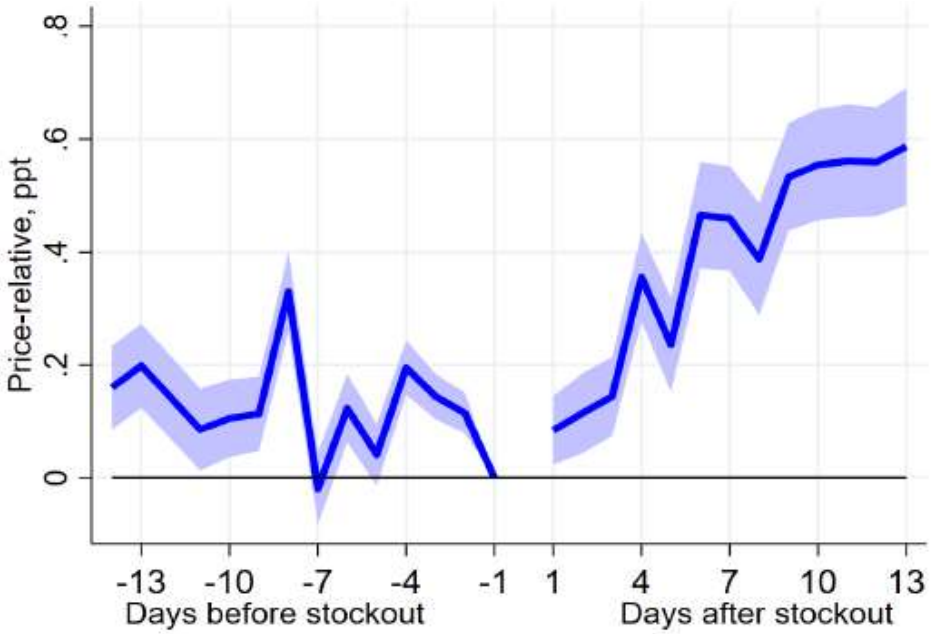
Result 2b: After temp stockouts prices tend to rise



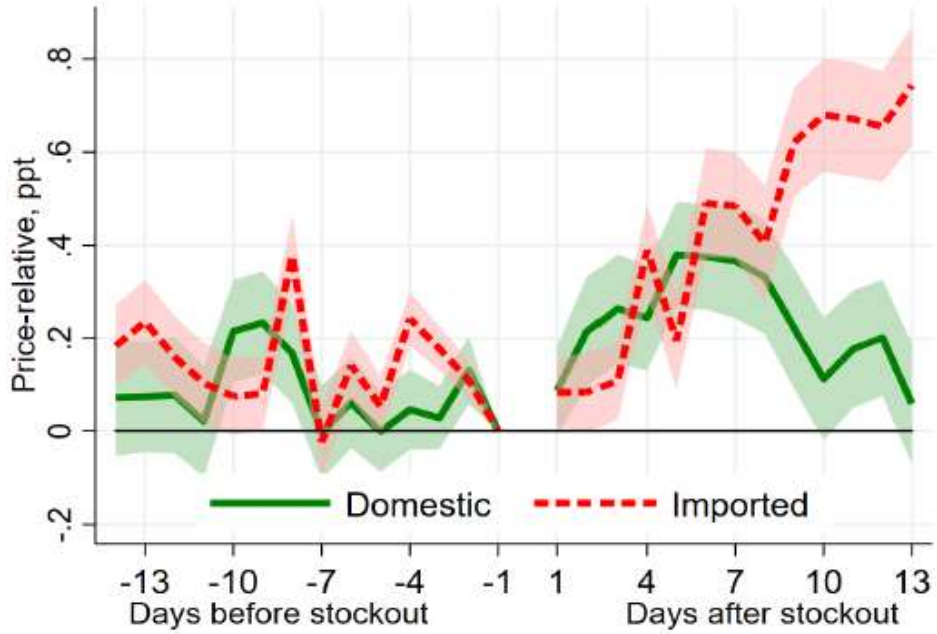
(a) All price changes

Price-relative = cum log p-change *t* days before/after day -1 relative to cum log price change for all goods in L3 sector

Result 2b: After temp stockouts prices tend to rise, especially for imported goods



(a) All price changes



(b) Domestic versus Imported Goods

Price-relative = cum log p-change *t* days before/after day -1 relative to cum log price change for all goods in sector

What can stockouts tell us about the *cost of replenishing* inventories?

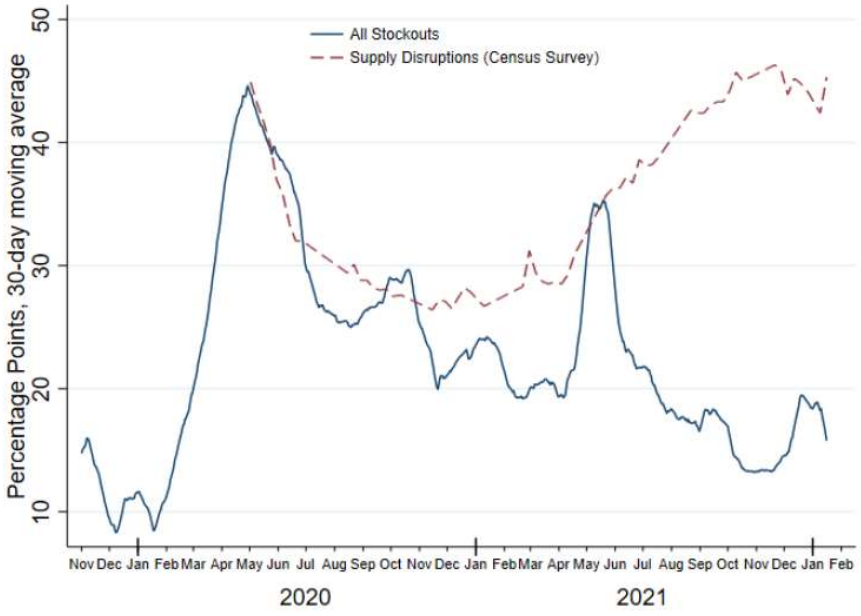
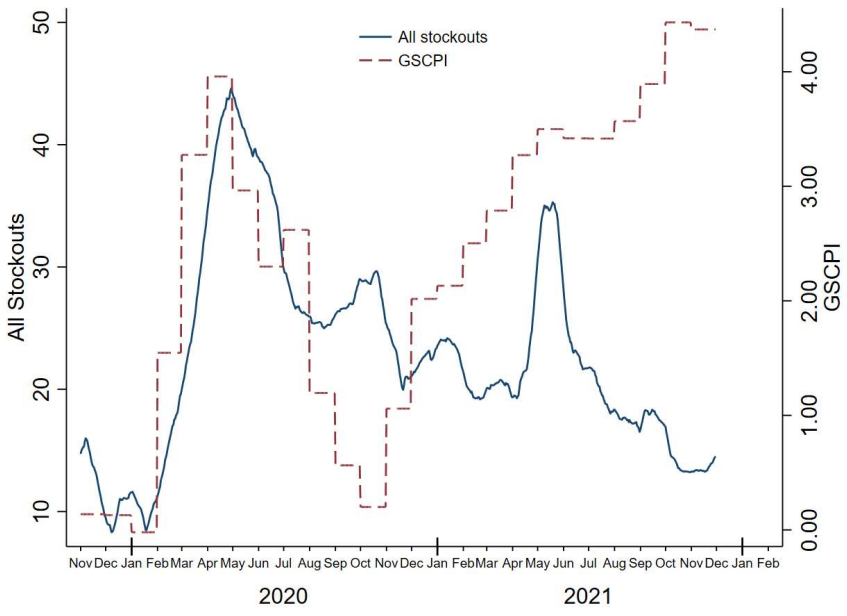


Figure A1: Stockouts (AOOS) vs. U.S. Census Survey of Small Business Disruptions



Source: Benigno et al. (2022) , index of global supply chain pressures

- Our stockouts matched surveys of "supply disruptions" closely until May 2021, but have diverged since
- Firms can adjust to changes in the replacement cost via stockouts and prices → we cannot infer the cost only from stockout dynamics
- We use a model to endogenize inventory decisions, and estimate cost based on observable OOS and prices

What can stockouts *and prices* tell us about the cost to replenish inventories?

- Model of monopolistic firm with inventories (builds on Kryvtsov and Midrigan, 2013)
  - Inventories help firm to manage incidence of stockouts → tradeoff: inventory-holding cost vs unable to meet demand
  - Convex cost of adjusting inventories → higher stockouts increase replacement costs
  - Allows for both changes in demand and supply to increase the inventory replacement cost

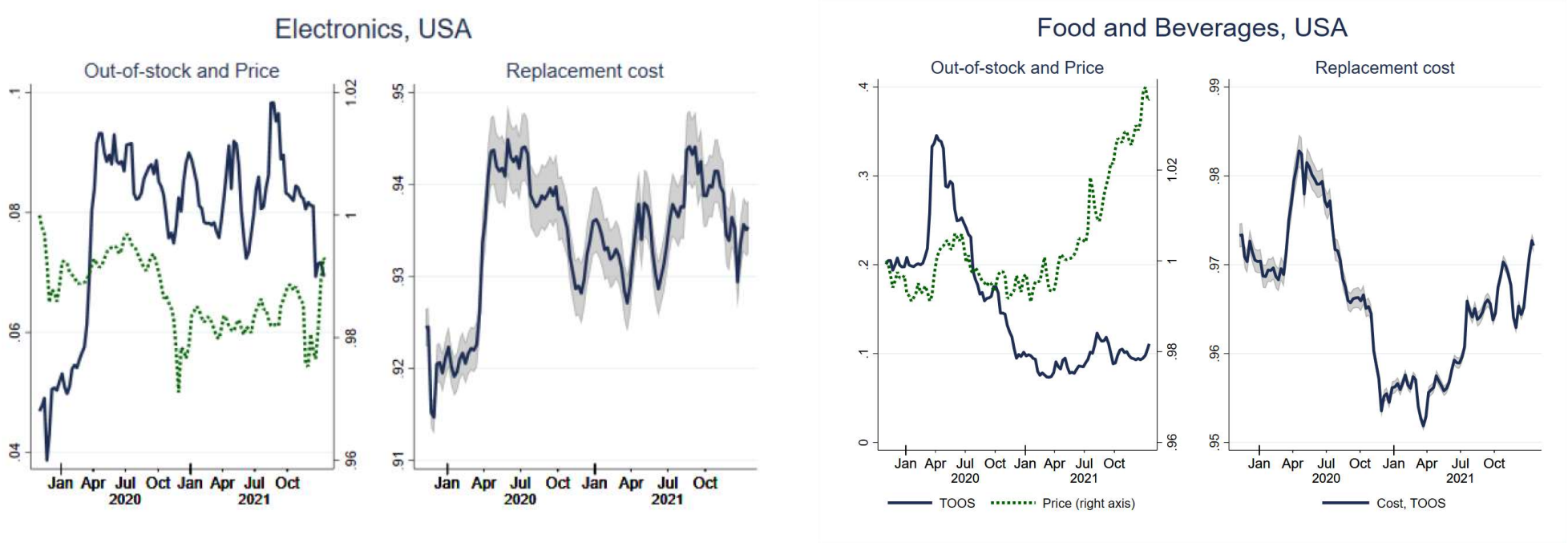
- FOC: probability of temporary stockout depends on firm's price and current/future replacement cost

$$\underbrace{\Psi'(v_{jt}(i))}_{\text{prob. of stockout}} = \frac{\Omega_{jt}(i) - (1-\delta_j)E_t\left[Q_{t,t+1}\Omega_{jt+1}(i)\right]}{P_{jt}(i) - (1-\delta_j)E_t\left[Q_{t,t+1}\Omega_{jt+1}(i)\right]}.$$

→ We can use the observed OOS and prices to estimate the cost to replenish inventories over time

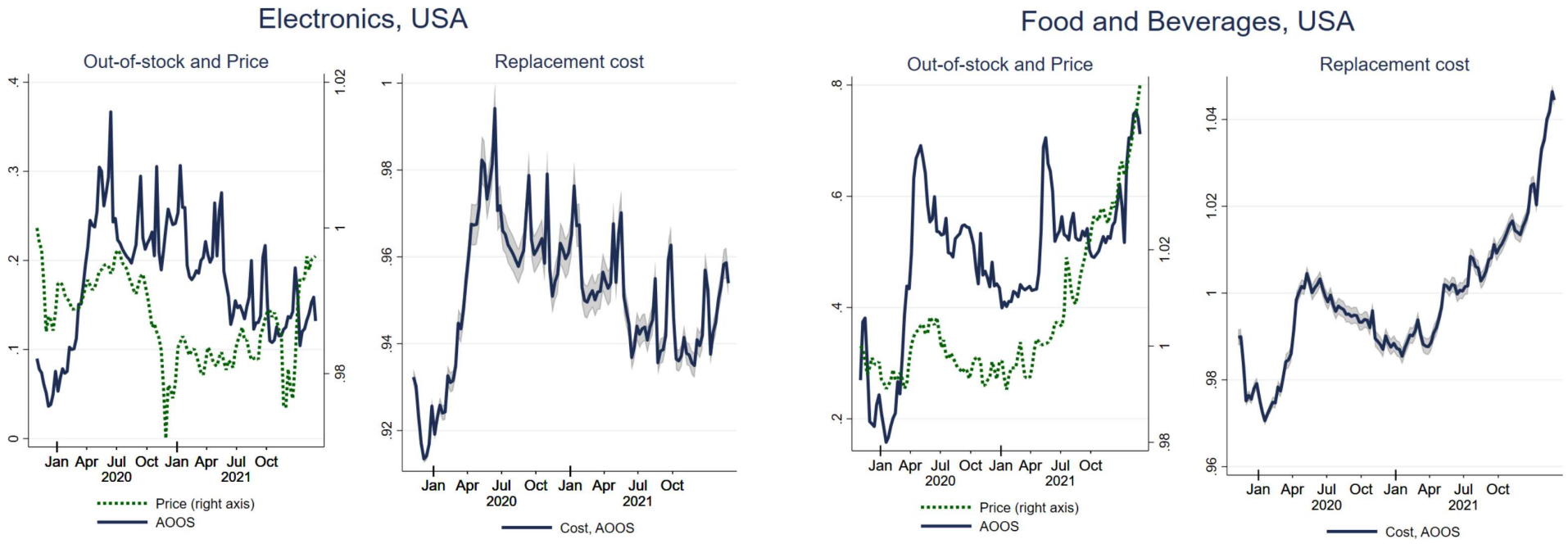
- Conditional on cost, prices and stockouts are negatively correlated → so co-movement of prices and stockouts suggests higher costs

Estimated Replacement Cost – Temporary Stockouts



- Electronics → cost dynamics similar to OOS because prices are relatively stable
- Food and Beverages → cost dynamics change significantly when we account for prices

Estimated Replacement Cost – All Stockouts



- Replacement cost increases more if we include permanent stockouts , particularly for Food and Beverages

Result 3: Inflationary impact is stronger, twice as high for imported goods

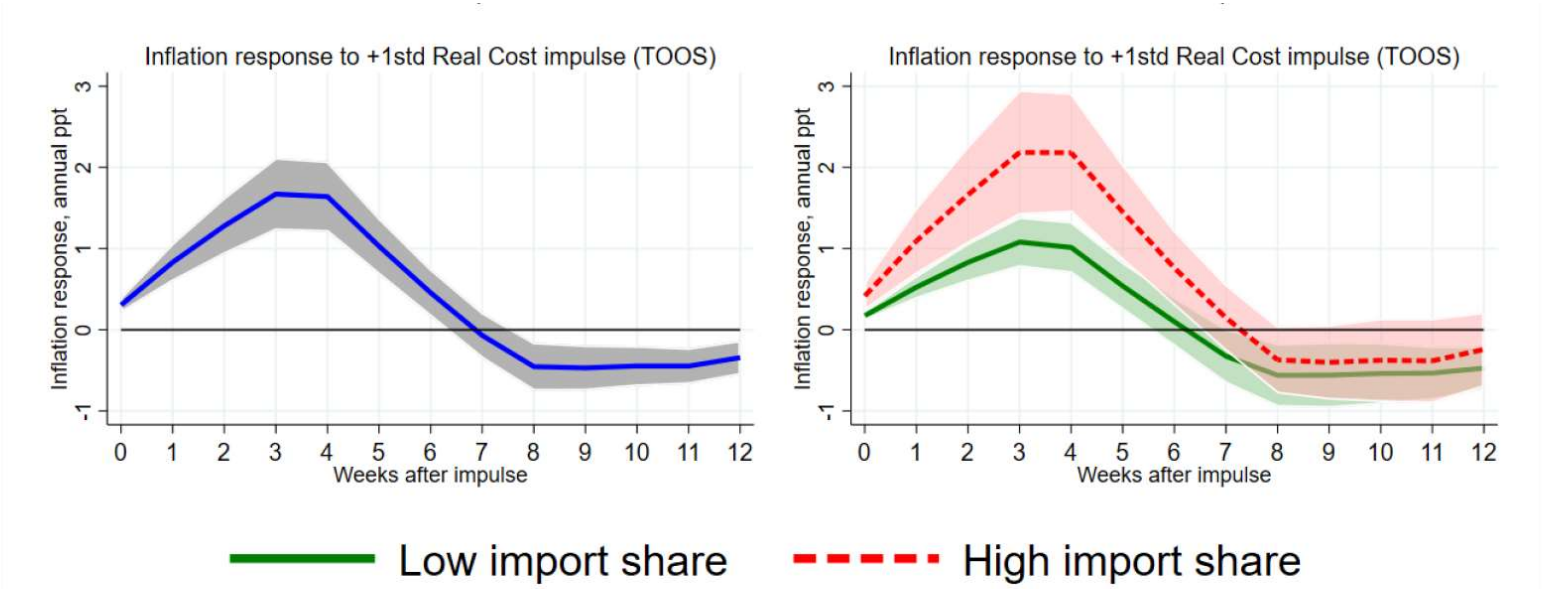


Figure 11: Responses to Real Replacement Cost Shocks in 3-Digit Sectors, in 7 Countries

- With endogenous stockouts

→ Inflation responses are stronger but less persistent

→ Inflation impact twice as high for imported goods

Key results and takeaways

- Widespread increase in shortages during the pandemic
- The composition and visibility of shortages changes over time → from temporary stockouts affecting nearly all categories to permanently discontinued goods concentrated in fewer sectors
- Shortages have economically significant inflationary effects, within 1 to 3 months
- Effects are larger and more persistent for imported goods and import-intensive sectors
- Co-movement of stockouts and prices suggest higher cost of replenishing inventories was an important driver of inflation in this period
  - Increasing again in Q1 2022