

# Prices and Stockouts during the Covid-19 Pandemic

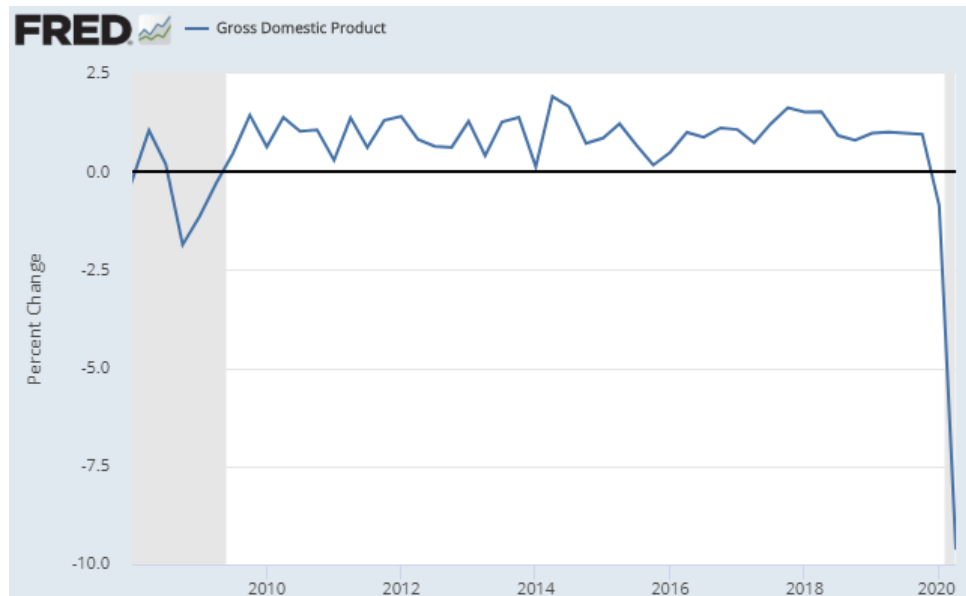
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Harvard Business School

Bank of Finland - September, 2020

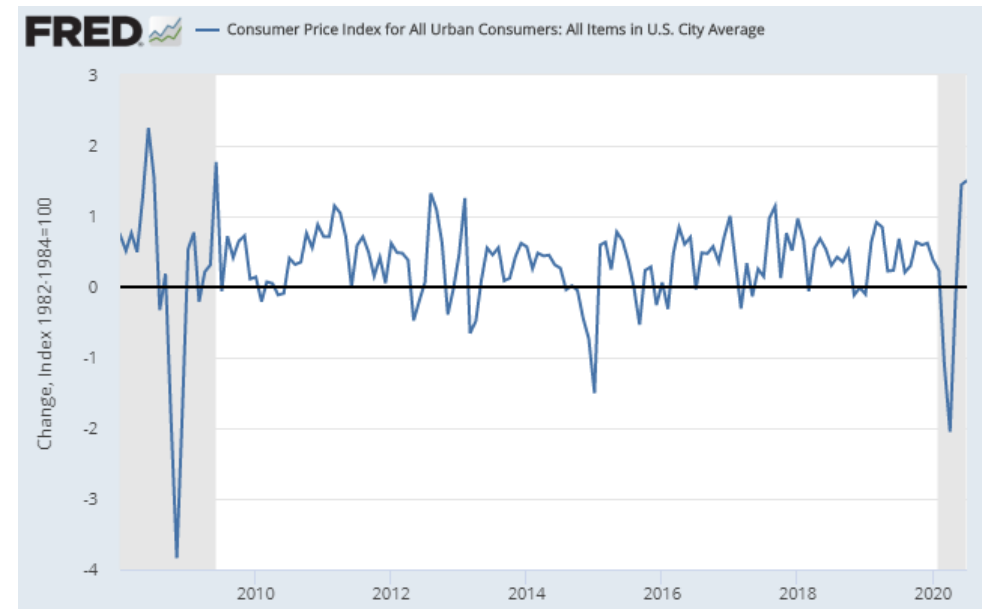
# Motivation

- We are experiencing the worst global recession since the Great Depression
- Output has collapsed but inflation remains relatively stable

US GDP (quarterly change)



US Monthly Inflation Rate



- What is really happening with inflation during Covid?
- Are supply disruptions putting upward pressure on prices?

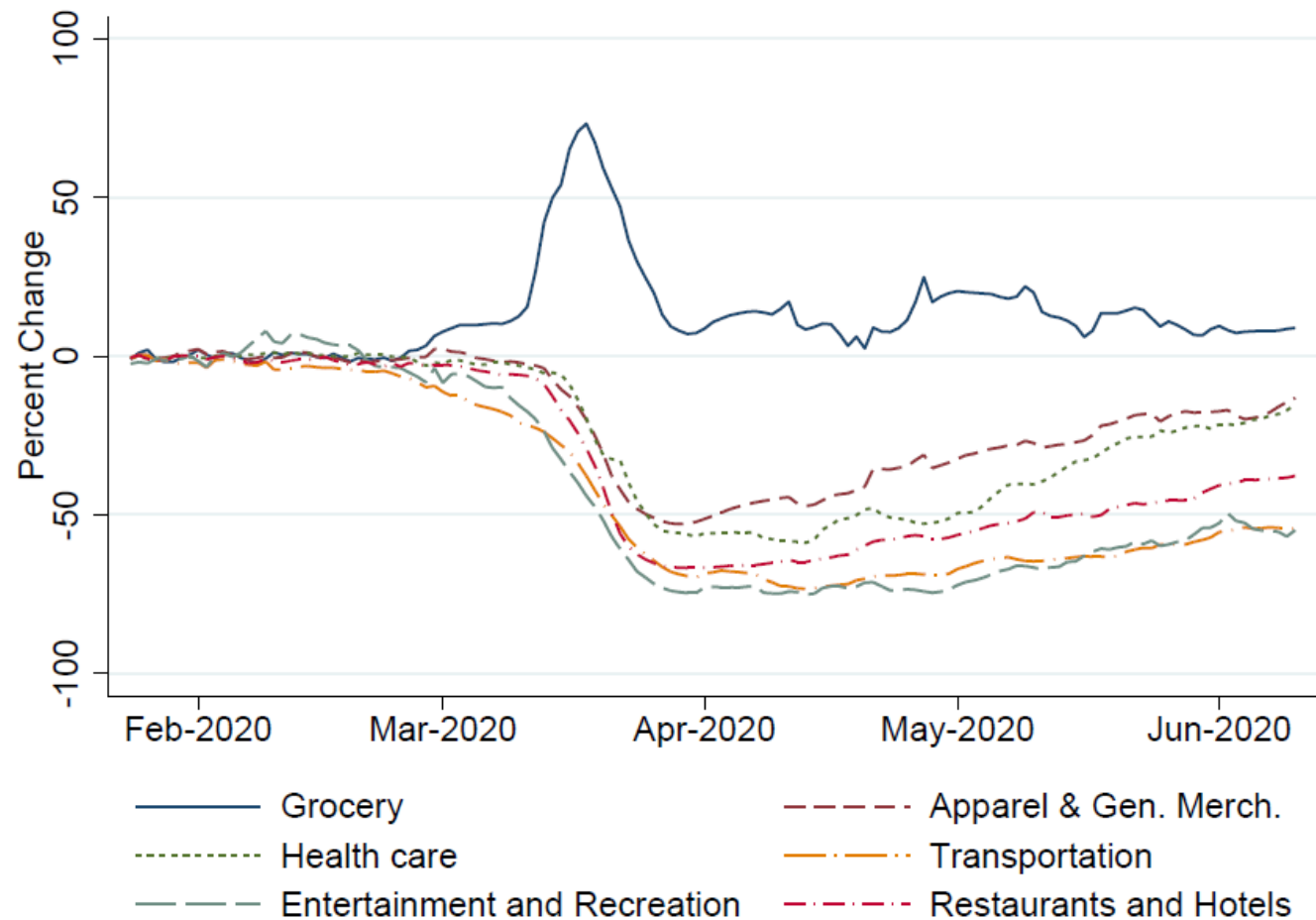
# Preview of Results

- Cavallo (2020) “Inflation with Covid Consumption Baskets”
  - **Covid inflation is higher than the official US CPI suggests**
    - Consumption patterns have changed dramatically → people are consuming more food (inflation) and less transportation and recreation (deflation)
    - Similar results in 12 out of 17 other countries
    - Inflation is highest for low-income households
    - Divergence in sectoral inflation rates suggest supply shocks are also affecting some sectors
- Cavallo & Kryvtsov (2020) “Stockouts and Prices during Covid”
  - We document a **sharp increase in retail stockouts** affecting many countries and sectors
  - Stockouts are **positively correlated with price increases** and lockdown intensities
  - Preliminary results seem consistent with a temporary cost shock

# Paper 1: “Inflation with Covid Consumption Baskets”

- Consumer Price Indices (CPIs) measure the price of a fixed basket of goods and services over time
- In most countries, this basket is updated once a year with data collected using expenditure surveys with a lag
  - In the US the basket weights were last updated in December 2019 with data collected in 2017-2018
- This is reasonable in normal times, but can severely bias inflation estimates during a crisis
  - Diewert & Fox (2020)
  - Tenreyro (2020), Lane (2020)

# US Consumption patterns have changed dramatically during Covid



[www.tracktherecovery.org](http://www.tracktherecovery.org)

- Cumulative expenditure change computed by “Opportunity Insights” from US credit and debit card transactions
- Similar results in other countries / papers
  - Carvalho et al (2020)
  - Baker et al (2020)
  - Andersen et al (2020)
  - Coibion et al (2020)

Figure 1: Changes in US Consumer Spending During the Pandemic

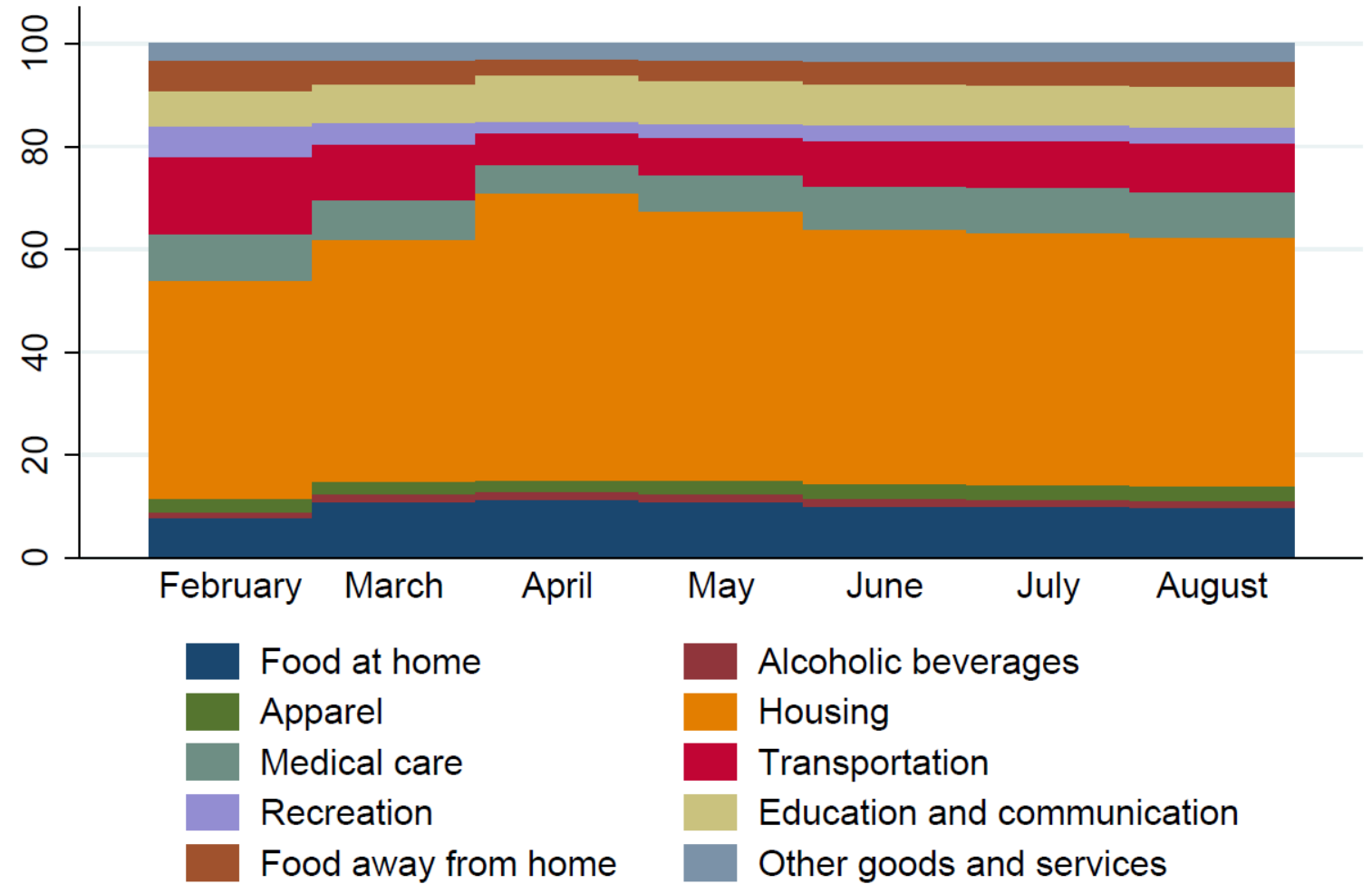
Source: Cavallo, Alberto. “[Inflation with Covid Consumption Baskets](#).” NBER Working Paper Series, No. 27352, July 2020.



# Covid Consumption Weights

$$s_t^i = \frac{P_t^i Q_t^i}{\sum_i P_t^i Q_t^i} = \frac{s_0^i \Delta e^i}{\sum_i s_0^i \Delta e^i}$$

## US Covid Weights



# The US Covid Basket – April 2020

CPI Category	Monthly CPI Inflation	Changes in weights		Incidence	
		Weight CPI	Weight Covid CPI	CPI	Covid CPI
Food at Home	2.67	7.58	11.28	0.20	0.30
Alcoholic Beverages	0.30	1.02	1.52	0.00	0.00
Apparel	-4.38	2.81	2.20	-0.12	-0.10
Housing	-0.03	42.11	55.80	-0.01	-0.02
Medical Care	0.28	8.83	5.60	0.02	0.02
Transportation	-4.97	15.74	6.25	-0.78	-0.31
Recreation	-0.27	5.82	2.23	-0.02	-0.01
Education and Communication	0.13	6.77	8.97	0.01	0.01
Food Away from Home	0.15	6.19	3.13	0.01	0.00
Other Goods and Services	-0.04	3.13	3.03	0.00	0.00

Divergence  
in inflation

Source: Cavallo, Alberto. "Inflation with Covid Consumption Baskets." NBER WP 27352, July 2020.

Table 2: US CPI Weights and Incidence - April 2020

- More weight on food, a sector experiencing more inflation
- Less weight on transportation, a sector experiencing significant deflation

# Impact on US Inflation

	Monthly Inflation Rate (1-month change, %)		Annual Inflation Rate (12-month change, %)	
	CPI	Covid CPI	CPI	Covid CPI
January	0.39	0.39	2.50	2.50
February	0.27	0.28	2.35	2.35
March	-0.22	-0.12	1.56	1.67
April	-0.69	-0.09	0.35	1.05
May	-0.02	0.11	0.13	0.95

Table 1: US Inflation Rates During the Covid Pandemic

	Monthly Inflation Rate (1-month change, %)		Annual Inflation Rate (12-month change, %)	
	Core CPI	Covid Core CPI	Core CPI	Covid Core CPI
January	0.40	0.40	2.27	2.27
February	0.47	0.47	2.37	2.36
March	0.02	0.04	2.10	2.12
April	-0.46	-0.21	1.43	1.71
May	-0.13	-0.01	1.20	1.59

Table A3: US Core Inflation Rates During the Covid Pandemic

Source: Cavallo, Alberto. "[Inflation with Covid Consumption Baskets](#)." NBER WP 27352, July 2020.

- By May, over 0.8% more inflation than measured by the CPI
- Similar results for Core inflation → less weight on some non-energy transportation and recreation sectors experiencing deflation



# Covid Inflation by Income Levels

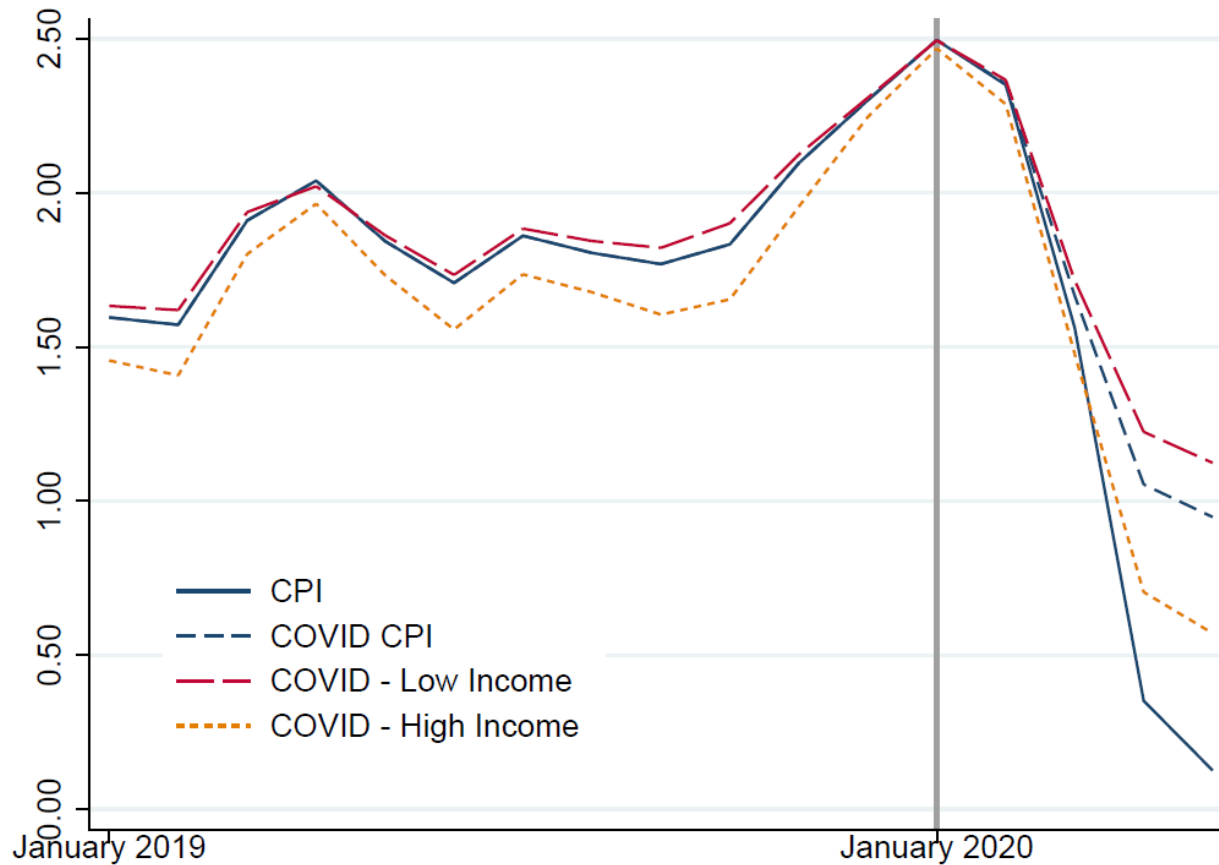


Figure 2: US Annual Inflation with Covid Expenditure Baskets

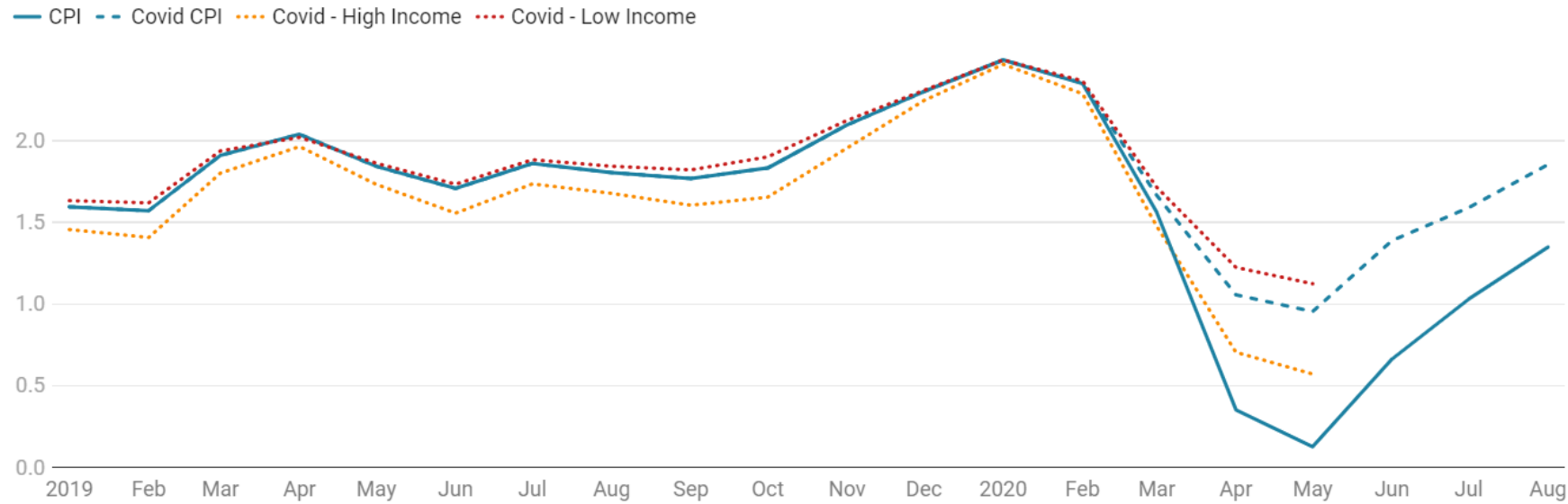
Source: Cavallo, Alberto. "[Inflation with Covid Consumption Baskets](#)." NBER WP 27352, July 2020.

- I use the 2018 BLS CEX survey to build CPI weights for the lowest and highest income quintiles
- Covid inflation is higher for low-income households
  - spend relatively more on food and less on transportation

# “Live” Results Online

- More up -to-date results in [https:// projects.iq.harvard.edu/ covid-cpi](https://projects.iq.harvard.edu/covid-cpi)

## US Covid Inflation (All-items, 12-month changes)

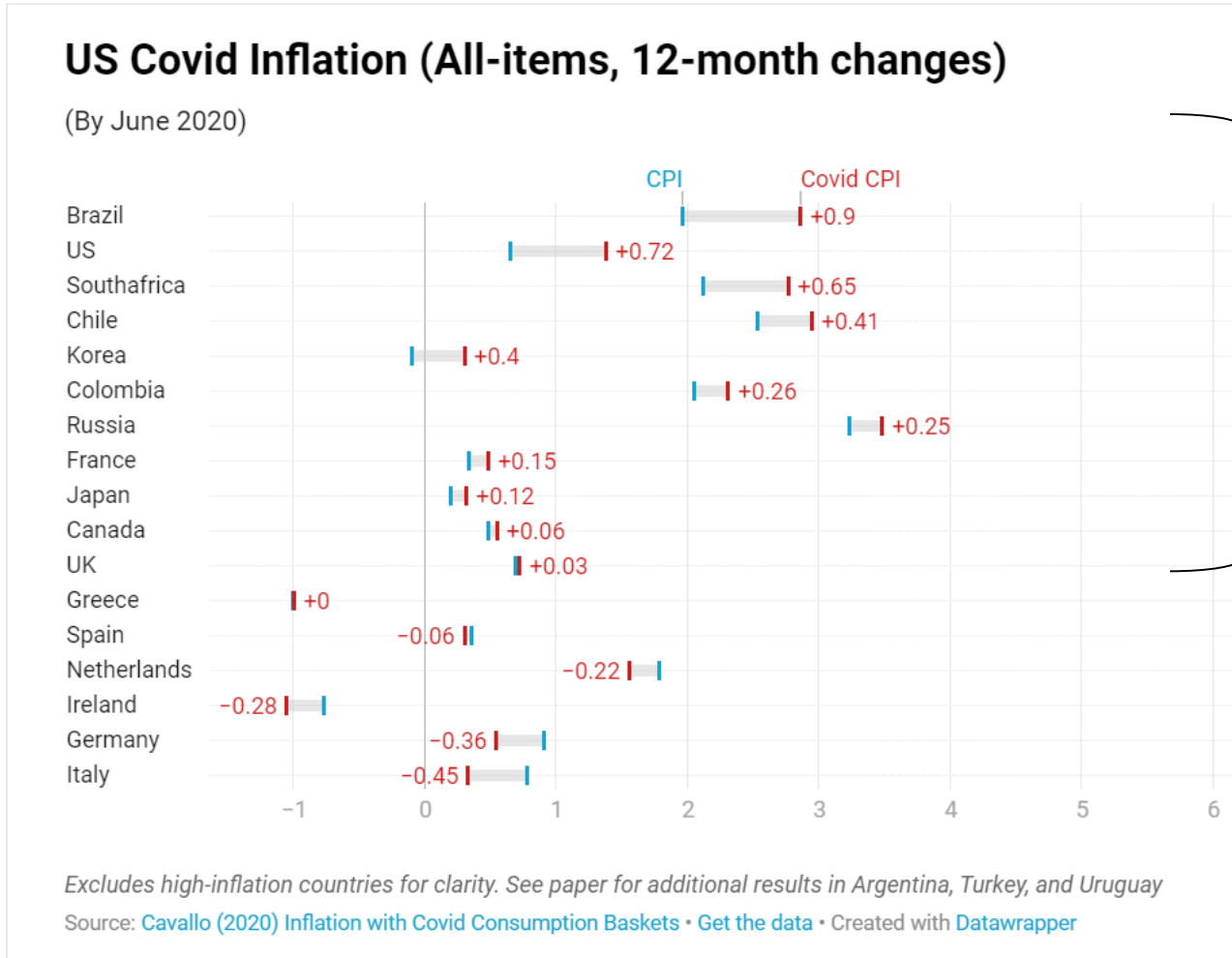


Note: The high-income and low-income series are not updated in real time because the data from opportunityinsights.org required to construct them are not publicly available.

Source: Cavallo (2020) Inflation with Covid Consumption Baskets • Get the data • Created with Datawrapper

# Covid inflation is higher in many other countries

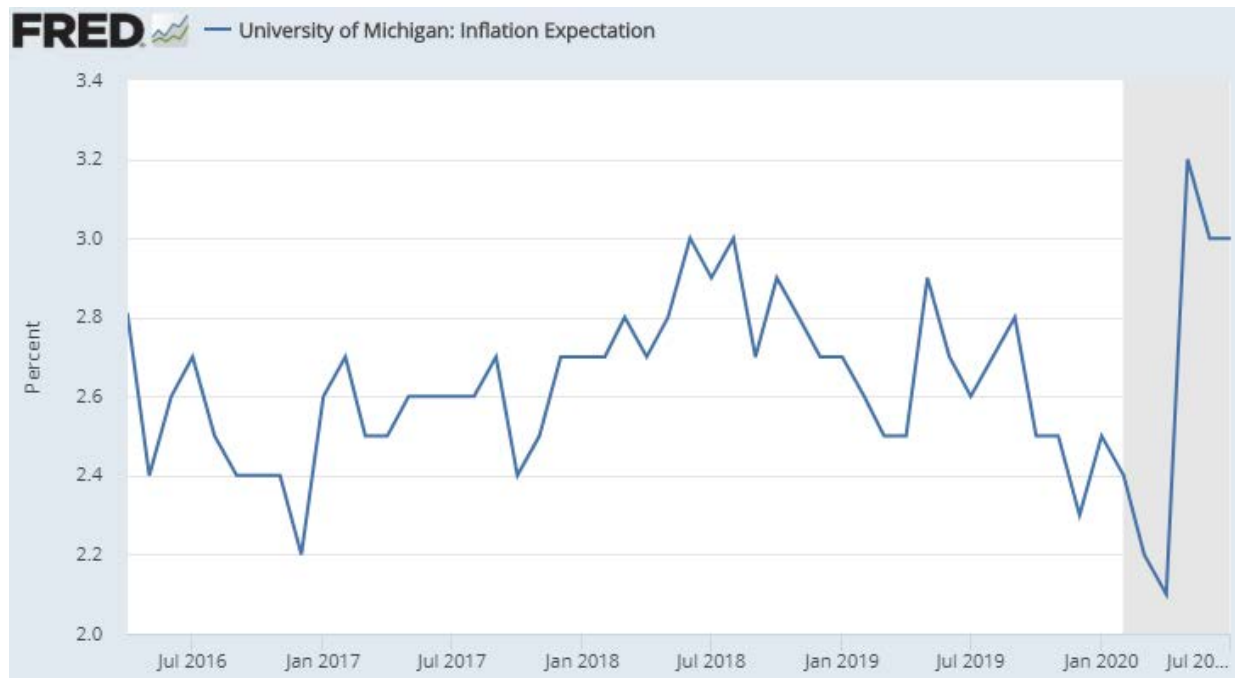
- I re-estimate Covid CPI weights in 17 other countries using the US expenditure dynamics
- Higher Covid inflation in 12 countries.



These countries are all experiencing similar divergence in sectoral inflation rates (food inflation coupled with transportation/ recreation deflation)

# Implications

- Cost of living has risen faster than the CPI suggests
  - Particularly for low-income households
- Helps explain recent spike in consumer inflation expectations



FEDERAL RESERVE BANK of NEW YORK

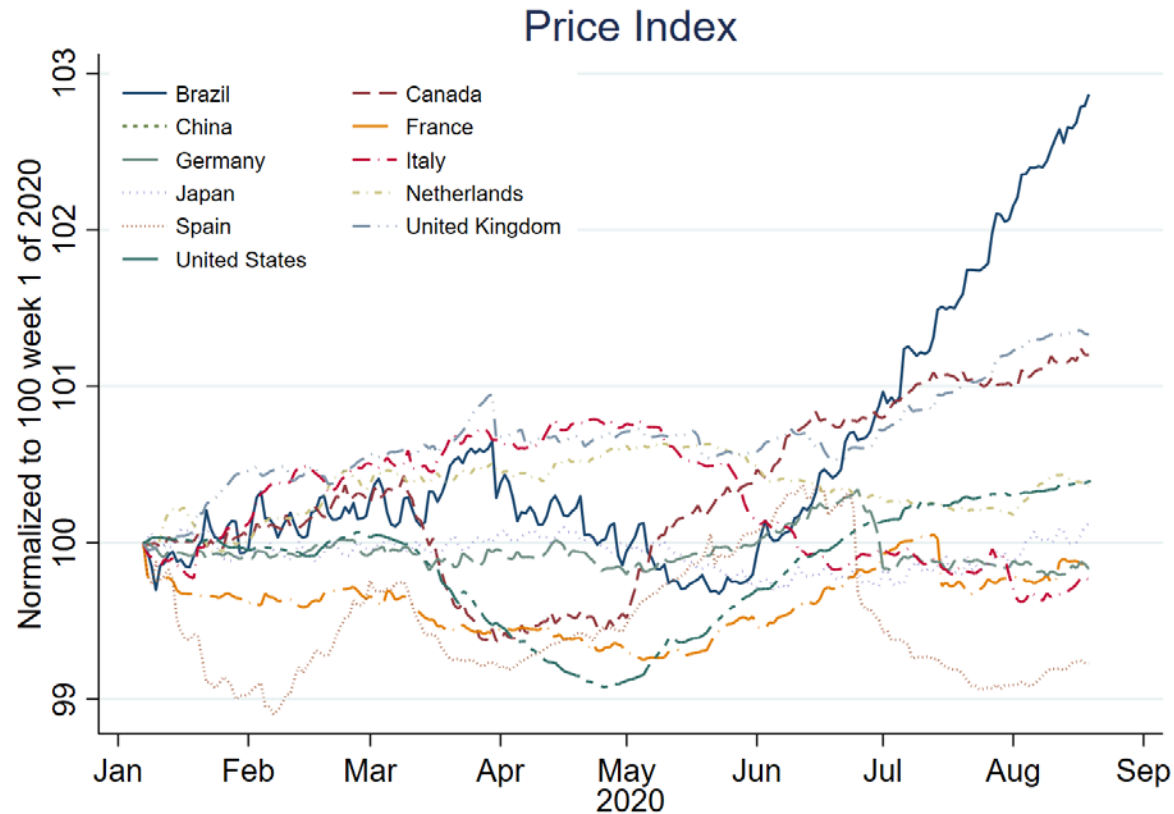
## Inflation Expectations Move Higher at the One- and Three-Year Horizons

The year-ahead median inflation expectation increased to 2.9 percent in July, from 2.7 percent in June, a level above its twelve-month trailing average of 2.5 percent. Similarly, the three-year-ahead median inflation expectation rose to 2.7 percent in July, from 2.5 percent in June. Respondents below age 40 drove the increase at both horizons. The measure of disagreement (the difference between the 75th and 25th percentiles of inflation expectations) also increased at both horizons in July.

- Findings depend on changes in weights + divergence in sectoral rates
- What is causing price increases (or lack of deflation) in some sectors?

# Paper 2: Stockouts and Supply Disruptions

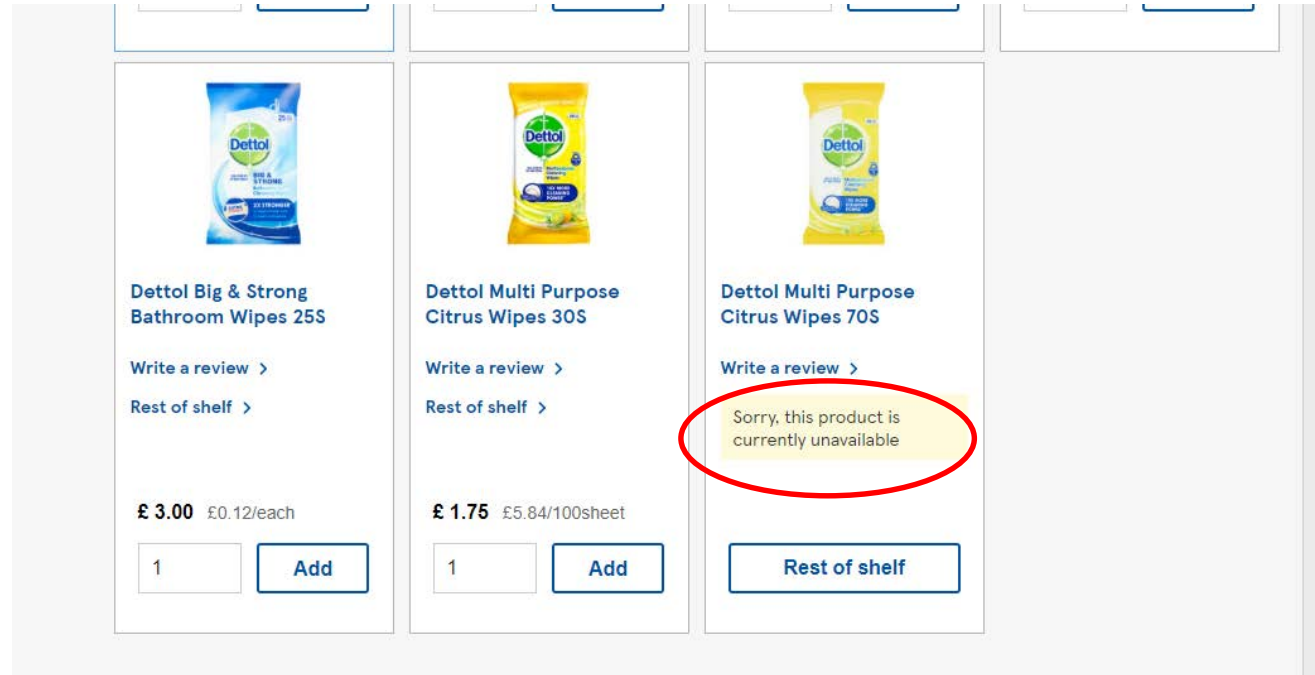
Cavallo & Kryvtsov (2020) “Stockouts and Prices during the Covid-19 Pandemic: Evidence from Online Micro Data” (preliminary results)



- Inflation rebound → higher prices in food, health, and more recently electronics
- Are supply disruptions driving some of these price increases?

# Out-of-Stock Indicator

- We use micro price data collected every day from the websites of large multi-channel retailers (Billion Prices Project)
- Some retailers show out-of-stock indicators



Note: This image illustrates the out of stock information, but this specific retailer may not be in the dataset

- We compute the  $oos_t = \frac{\# \text{ out of stock}_t}{\# \text{ total products}_t}$
- We start at the COICOP 4 digit level and aggregate up using official CPI weights

# Prices and Stockouts Data

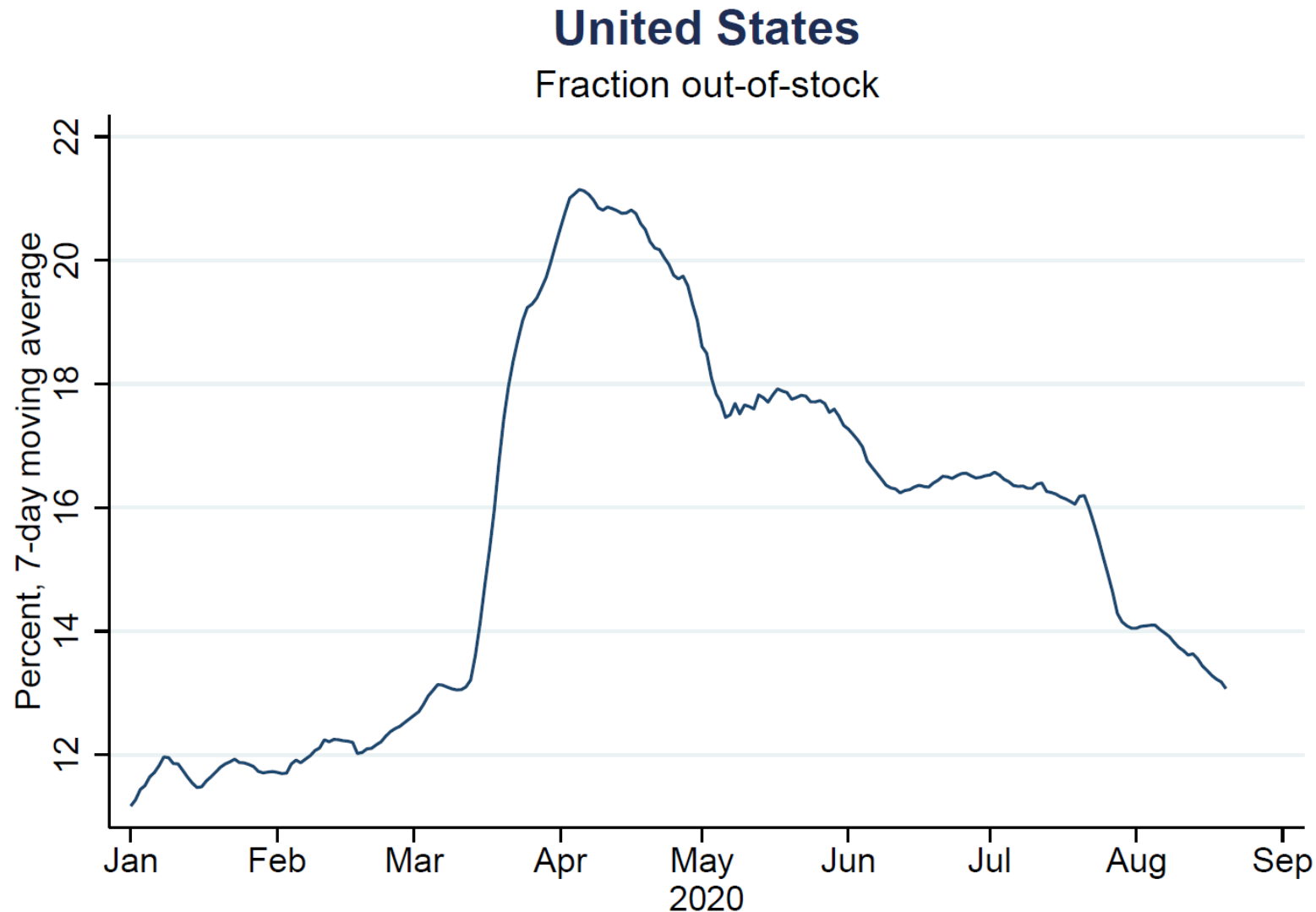
- We focus on a subset of 124 retailers in 11 countries that show “out of stock” information for each product

Table 1: Micro Data by Country and Sector

	Products	Retailers	OOS, %	Fraction P-ch (%)	Abs Size P-ch (%)	Share P Inc	Inflation Mom (%)
All	2,818,536	124	11.83	2.19	20.54	0.50	-0.18
Brazil	341,928	21	18.02	3.90	19.67	0.52	0.03
Canada	284,396	10	17.16	1.39	33.83	0.52	-0.05
China	140,042	3	5.59	1.00	20.38	0.49	-0.14
France	206,633	18	9.50	1.19	17.55	0.51	-0.21
Germany	385,127	13	13.45	1.75	14.38	0.52	-0.21
Italy	78,272	7	4.97	3.11	21.73	0.51	0.00
Japan	115,363	7	4.26	4.50	13.20	0.40	-0.42
Netherlands	97,366	7	20.93	0.74	20.10	0.55	0.01
Spain	158,105	8	10.16	2.85	16.65	0.52	-0.31
United Kingdom	178,513	13	10.75	1.02	28.91	0.50	-0.25
United States	832,791	17	15.38	2.70	19.58	0.46	-0.40
Food and Beverages	335,162	78	11.82	2.06	20.25	0.52	0.07
Alcohol & Tobacco	36,029	39	8.51	1.66	15.49	0.52	-0.05
Apparel	294,161	68	7.84	2.78	32.65	0.44	-1.37
Furnishings & Household	994,376	106	13.76	2.79	17.90	0.48	-0.02
Health	120,930	112	10.40	1.03	18.78	0.54	0.07
Electronics	476,084	113	19.87	3.12	16.06	0.48	0.10
Other Goods	320,466	112	12.65	2.06	23.17	0.50	-0.07

Source: Cavallo & Kryvtsov (2020) “Stockouts and Prices during the Covid-19 Pandemic: Evidence from Online Micro Data” (Preliminary Results)

# Aggregate Stockout Dynamics

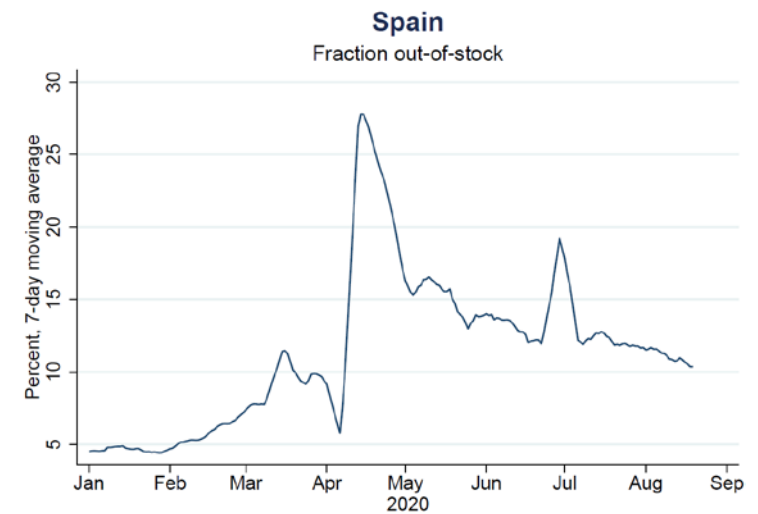
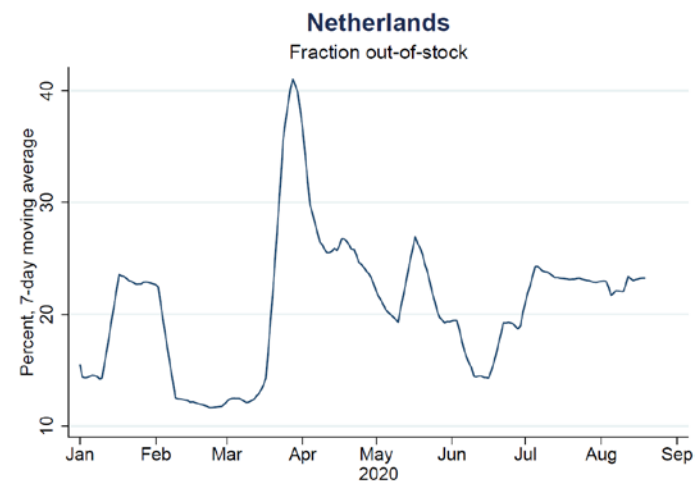
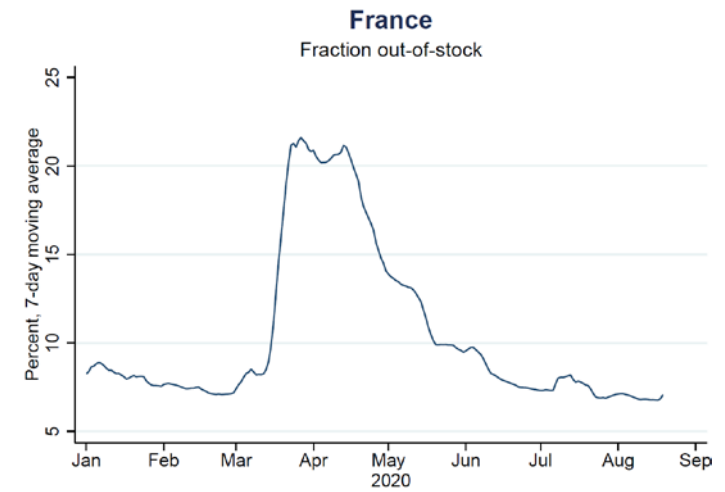
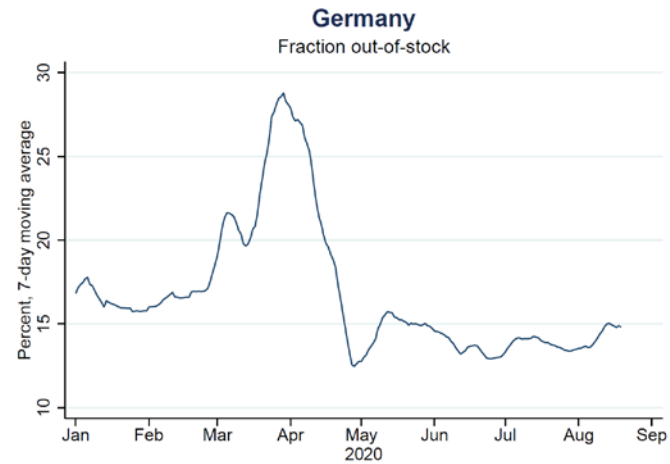
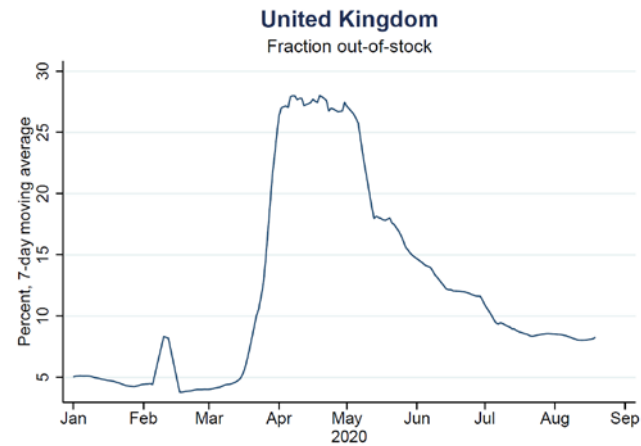


- Sudden increase: from 13% to 21% in late March
- Gradual decline → persistence



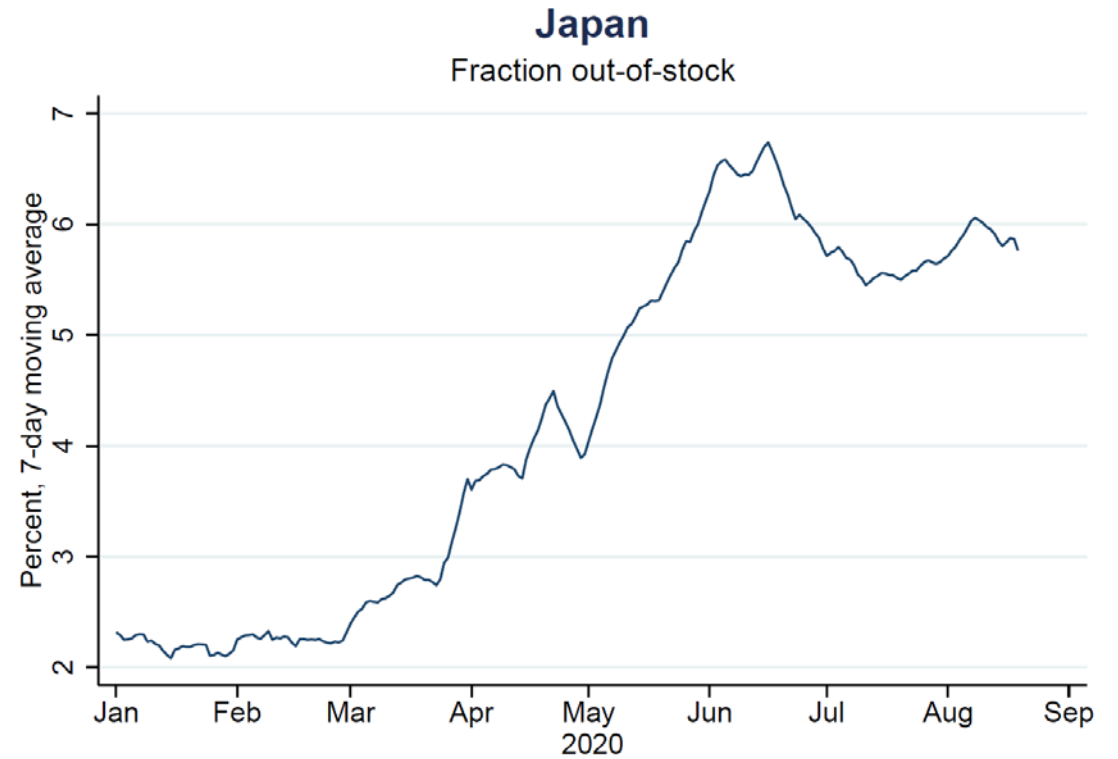
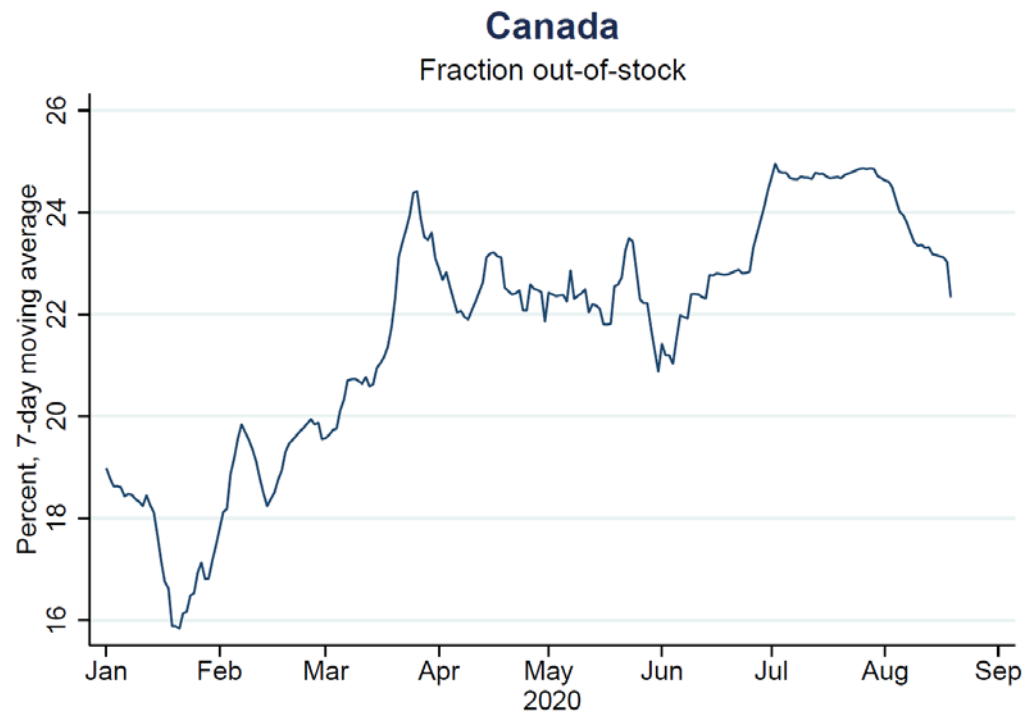


# Similar pattern, but faster recovery in Europe



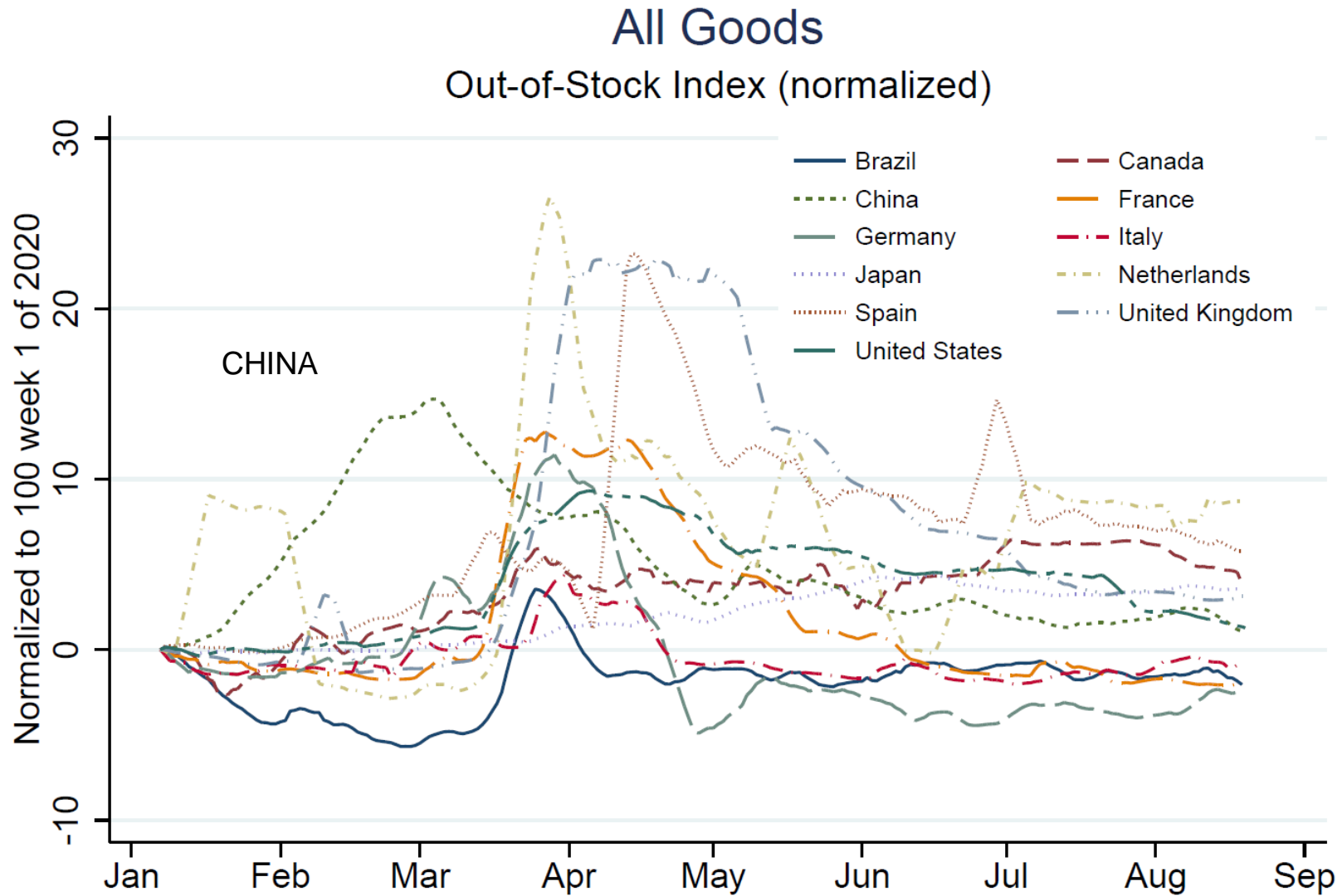


# Japan and Canada had more gradual and persistent increases



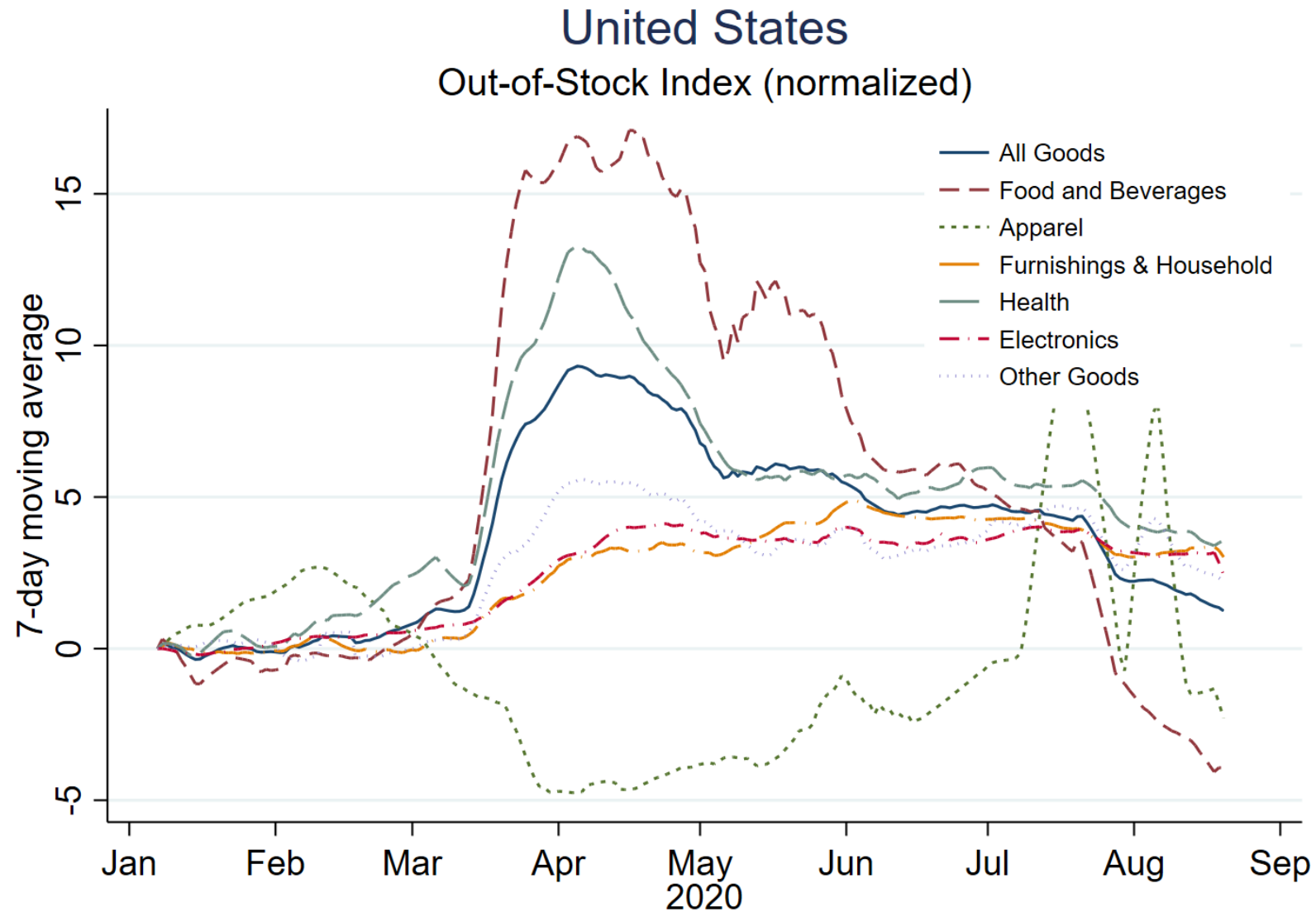


# China peaks first & Europe follows



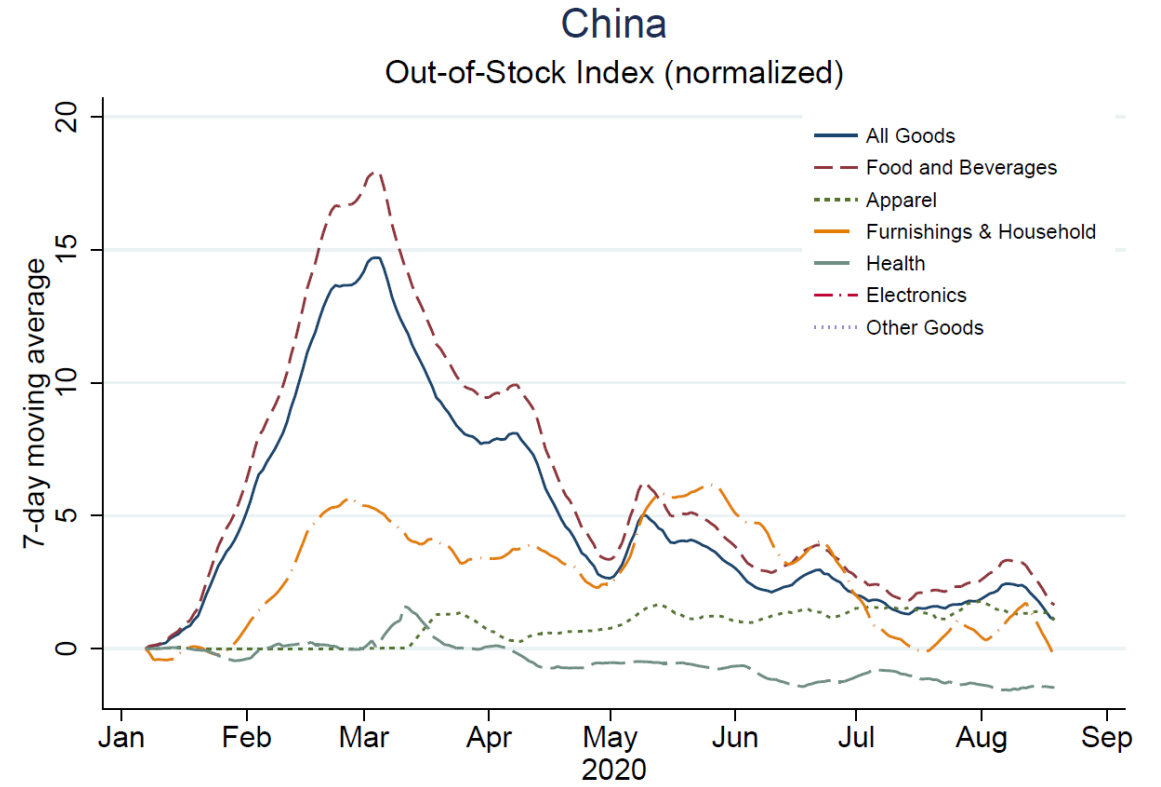
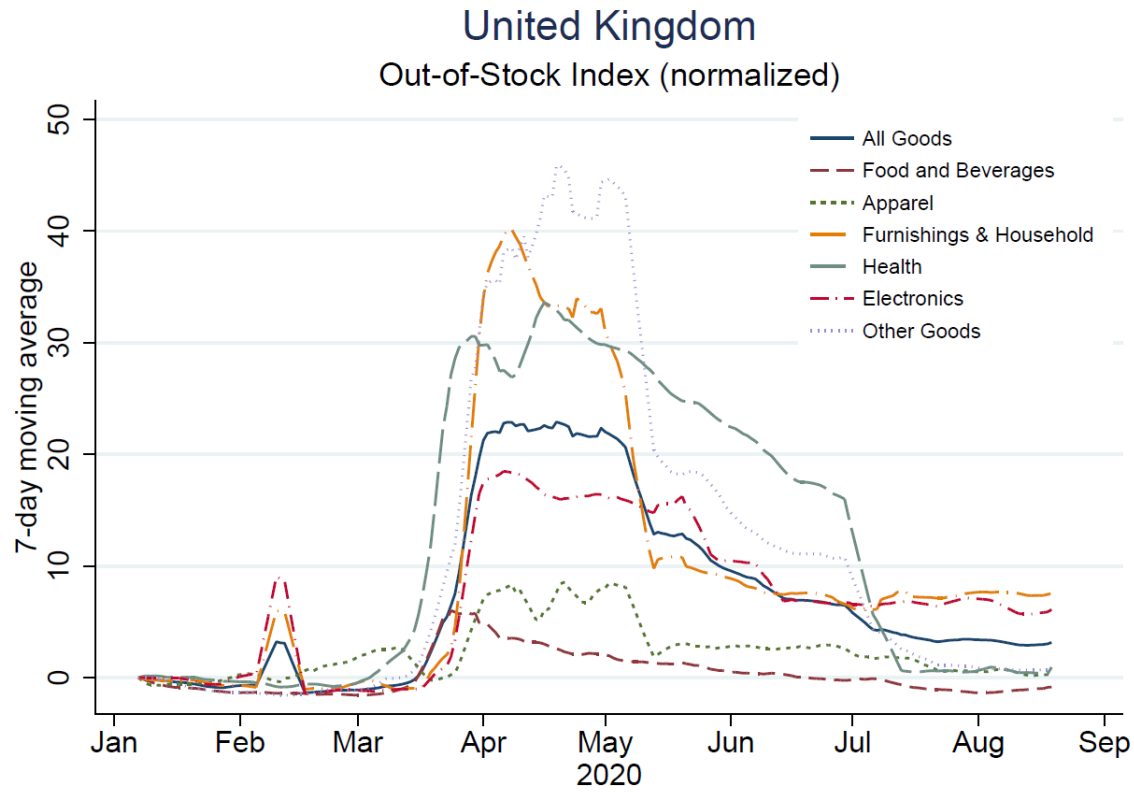


# All sectors experienced more stockouts in the US (except for Apparel)





# Patterns are similar in other countries, but different sectors affected



Source: Cavallo & Kryvtsov (2020) "Stockouts and Prices during the Covid-19 Pandemic: Evidence from Online Micro Data" (Preliminary Results)

# Co-movement of OOS and Prices

- Regression using sector -level data, country and sector fixed effects
- OOS is positively correlated with monthly inflation
  - OOS is positively correlated with price increases and their size
  - OOS is negatively correlated with price decreases and their size
- OOS is positively correlated with the lockdown intensity

Table 2: Determinants of OOS

	OOS (1)	OOS (2)
Inflation (mom, %)	0.474 (0.083)	
Fraction Price Increases (%)		0.053 (0.037)
Fraction Price Decreases (%)		-0.183 (0.036)
Abs. Size Price Increases (%)		0.013 (0.004)
Abs. Size Price Decreases (%)		-0.085 (0.011)
Lockdown Stringency	0.050 (0.003)	0.055 (0.003)
Constant	14.725 (0.320)	13.689 (0.356)
N	11,292	9,418
r <sup>2</sup>	0.468	0.499
Level	L1 Sector	L1 Sector
FE	Country - Sector	Country - Sector

# What drives joint price and OOS behavior?

- Study pandemic in a New Keynesian model with inventories
- Eichenbaum, Rebelo, Trabandt (2020): epidemic in NK models
- Kryvtsov and Midrigan (2010, 2013): NK models with inventories
  - ▶ stockout-avoidance motive for holding inventories
  - ▶ inventory data informative about drivers of business cycles
- Today: intuition for comovement of prices and stockouts



# Firms

- Technology:  $y_t(i) = l_t(i)$
- Choose price  $p_t(i)$  and inventory stock  $z_t(i)$  before learning  $v_t(i)$ 
  - ▶  $\log v_t(i) \sim \text{i.i.d. } N(0, \sigma_v^2)$
  - ▶ **stock out** if  $v_t(i) \geq v_t^*$
- Sell  $q(p, z, v) = \min\left(v \left(\frac{p}{P}\right)^{-\theta} c, z\right)$
- Expected sales

$$R_{t+s}(p_t, z_{t+s}) = \int_0^1 \min\left(v_{t+s} \left(\frac{p_t}{P_{t+s}}\right)^{-\theta} c_{t+s}, z_{t+s}\right) dF(v_{t+s})$$



# Pandemic effects

$$\underbrace{1 - F(v^*)}_{\text{prob. stockout (-)}} = \frac{1 - \frac{1-\delta}{1+r} \frac{W'}{W}}{\underbrace{\frac{p}{W}}_{\text{markup(+)}} - \frac{1-\delta}{1+r} \underbrace{\frac{W'}{W}}_{\Delta\text{cost(+)}}}$$

## Initial response to pandemic

Markup	Cost	$\Delta\text{Cost}$	I-S ratio	OOS	Agg price
$\frac{p}{W}$	$W$	$\frac{W'}{W}$	$v^*$	$1 - F(v^*)$	$P$

### Data

					$\nearrow$	$\searrow$ <b>or</b> $\nearrow$
Demand fall	$\nearrow$	$\searrow$	—	$\nearrow$	$\searrow$	$\searrow$
Temp cost increase	$\searrow$	$\nearrow$	$\searrow$	$\searrow$	$\nearrow$	$\nearrow$
Perm cost increase	$\searrow$	$\nearrow$	$\nearrow$	$\nearrow$	$\searrow$	$\nearrow$

## Next steps

- Use the model to characterize the nature of sector -level shocks based on the joint behavior of stockouts, prices and other observables
  - Challenge: differentiate negative supply shock from positive demand shock
- Study stockout dynamics across sectors and countries:
  - Health & lockdown indicators
  - Product durability
  - Trade disruptions
  - Survey estimates of sector -level supply vs demand disruptions

# Concluding Remarks

- Covid inflation has remained surprisingly “resilient”, particularly when we take into account changes in consumption patterns.
- The sharp increases in retail stockouts are correlated with price increases and lockdown intensities
- Results suggest supply disruptions are playing an important role in this crisis → likely to continue affecting inflation dynamics in the future