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

Alberto Cavallo
Harvard Business School

Oleksiy Kryvtsov
Bank of Canada

Federal Reserve Bank of San Francisco “Macroeconomics and Monetary Policy” Annual Conference
25 March 2022

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

- Inflation during Covid: fell, quickly rebounded, reached decades high by end 2021

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

- Analyze two high-frequency measures of consumer product shortages in 7 countries
  - temporary stockouts, discontinued products

- Widespread 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
Analyze two high-frequency measures of consumer product shortages in 7 countries
  • temporary stockouts, discontinued products

Widespread 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 product shortages associated with inflation?

Do inflationary effects reflect supply-chain disruptions?

Do retailers pass through rising costs to prices or to shortages?
Paper summary

- Analyze two high-frequency measures of consumer product shortages in 7 countries
  - temporary stockouts, discontinued products

- Widespread 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 product shortages associated with inflation? YES

- Do inflationary effects reflect supply-chain disruptions? YES

- Do retailers pass through rising costs to prices or to shortages? YES, BOTH
Prices and stockouts micro data

- We use daily product data from The Billion Prices Project, currently collected by PriceStats
- 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>
```
We focus on 70 retailers in 7 countries that show “out of stock” information.

<table>
<thead>
<tr>
<th>Countries and sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sectors:</strong> Food &amp; Beverages, Furnishings &amp; Household, Health, Electronics, Other goods</td>
</tr>
<tr>
<td><strong>Not included:</strong> Alcohol &amp; Tobacco, Apparel, Cars, Gasoline</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Products</th>
<th>Retailers</th>
<th>Coverage of All CPI Weights, (%)</th>
<th>Coverage of Goods CPI Weights, (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>194,151</td>
<td>27</td>
<td>80</td>
</tr>
<tr>
<td>China</td>
<td>49,685</td>
<td>38</td>
<td>76</td>
</tr>
<tr>
<td>France</td>
<td>372,962</td>
<td>32</td>
<td>63</td>
</tr>
<tr>
<td>Germany</td>
<td>297,320</td>
<td>27</td>
<td>52</td>
</tr>
<tr>
<td>Japan</td>
<td>95,313</td>
<td>30</td>
<td>68</td>
</tr>
<tr>
<td>Spain</td>
<td>171,400</td>
<td>31</td>
<td>56</td>
</tr>
<tr>
<td>USA</td>
<td>777,554</td>
<td>21</td>
<td>62</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td>1,958,385</td>
<td>29</td>
<td>65</td>
</tr>
</tbody>
</table>
Measuring shortages in retail (sector $j$, country $c$, date $t$)

Temporary Stockouts ($TOOS_{jc,t}$) = \( \frac{\# \text{ out of stock }_{jc,t}}{\# \text{ total products }_{jc,t}} \)

Figure 1: Identifying Stockouts on a Retailer’s Website
Measuring shortages in retail (sector $j$, country $c$, date $t$)

Temporary Stockouts ($TOOS_{jc,t}$) = \frac{\text{# out of stock}_{jc,t}}{\text{# total products}_{jc,t}}

Permanent Stockouts ($POOS_{jc,t}$) = 1 - \frac{\text{# total products}_{jc,t}}{\text{# total products}_{jc,Jan-2020}}

Figure 1: Identifying Stockouts on a Retailer’s Website
Measuring shortages in retail (sector $j$, country $c$, date $t$)

Temporary Stockouts ($TOOS_{jc,t}$) = \( \frac{\# \text{out of stock}_{jc,t}}{\# \text{total products}_{jc,t}} \)

Permanent Stockouts ($POOS_{jc,t}$) = \( 1 - \frac{\# \text{total products}_{jc,t}}{\# \text{total products}_{jc, Jan-2020}} \)

All Stockouts = $TOOS_{jc,t} + POOS_{jc,t}$

Figure 1: Identifying Stockouts on a Retailer’s Website
Stockout dynamics in the United States

(a) All Stockouts

(b) Temporary and Permanent Stockouts
Stockout dynamics in 7 countries

(a) Temporary Stockouts

(b) Permanent Stockouts
In the United States, stockouts are more persistent in Food and Electronics.
Are product shortages associated with inflation?
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):

  $$X_{cj,t+h} - X_{cj,t-1} = c^{(h)} + \sum_{l=0}^{L} \beta_{l}^{(h)} \epsilon_{cj,t-l} + \sum_{n=1}^{N} \delta_{n}^{(h)} X_{cj,t-n} + D_{cj} + error^{(h)}_{cj,t}$$

  - $X_{cj,t}$ is monthly inflation rate or stockout rate (TOOS or POOS)
  - $D_{cj}$ are sector-country fixed effects
  - $\beta_{l}^{(h)}$ provide the estimated impulse response at horizon $h$
Doubling stockouts from 10% to 20% increases sector inflation by 1.6 ppt (annualized rate)

Responses to +1std OOS impulse

TOOS response to +1std TOOS impulse

POOS response to +1std POOS impulse
Doubling stockouts from 10% to 20% increases sector inflation by 1.6 ppt (annualized rate)
Supply disruptions during Covid impacted imported goods more domestically supplied goods:
  * Imported goods held in inventories twice as long (Alessandria, Kaboski, Midrigan, 2010)
  * U.S. Census Small Business Pulse Survey: more frequent/longer delays by foreign suppliers
  * Benigno et al. (2022): evidence from index of global supply chain pressures
  * Alessandria et al. (2022): shipping delays can raise prices, especially for imported goods

Do inflationary effects reflect supply-chain disruptions?
Do inflationary effects reflect supply-chain disruptions?

- Supply disruptions during Covid impacted imported goods more domestically supplied goods:
  - Imported goods held in inventories twice as long (Alessandria, Kaboski, Midrigan, 2010)
  - U.S. Census Small Business Pulse Survey: more frequent/longer delays by foreign suppliers
  - Benigno et al. (2022): evidence from index of global supply chain pressures
  - Alessandria et al. (2022): shipping delays can raise prices, especially for imported goods

- Differentiate goods by origin:
  1. Split 235 sectors (7 countries) into groups below/above weighted median import share (0.24)
     - Low shares: China, Japan, USA; unprocessed food, plants, printed material
     - High shares: Canada, Germany; video/audio equipment, furniture, jewelry and watches
  2. Micro evidence from a large U.S. retailer: imported vs domestic products
Responses to +1std OOS impulse: sectors with low/high import share

World Input-Output Database: Import Share in Total Consumption = Imports / (Output + Imports – Exports)
Micro evidence from a large U.S. retailer

<table>
<thead>
<tr>
<th></th>
<th>U.S. Retailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of products</td>
<td>16,953</td>
</tr>
<tr>
<td>imported</td>
<td>12,275</td>
</tr>
<tr>
<td>domestic</td>
<td>4,678</td>
</tr>
<tr>
<td>Fraction of stockouts, %</td>
<td>5.6</td>
</tr>
<tr>
<td>imported</td>
<td>5.5</td>
</tr>
<tr>
<td>domestic</td>
<td>4.1</td>
</tr>
<tr>
<td>Stockout duration, days</td>
<td>27.6</td>
</tr>
<tr>
<td>imported</td>
<td>26.3</td>
</tr>
<tr>
<td>domestic</td>
<td>18.2</td>
</tr>
<tr>
<td>Product inflation, ann %</td>
<td>0.86</td>
</tr>
<tr>
<td>imported</td>
<td>2.19</td>
</tr>
<tr>
<td>domestic</td>
<td>-1.53</td>
</tr>
</tbody>
</table>
Micro evidence from a large U.S. retailer

<table>
<thead>
<tr>
<th></th>
<th>U.S. Retailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of products</td>
<td>16,953</td>
</tr>
<tr>
<td>imported</td>
<td>12,275</td>
</tr>
<tr>
<td>domestic</td>
<td>4,678</td>
</tr>
<tr>
<td>Fraction of stockouts, %</td>
<td>5.6</td>
</tr>
<tr>
<td>imported</td>
<td>5.5</td>
</tr>
<tr>
<td>domestic</td>
<td>4.1</td>
</tr>
<tr>
<td>Stockout duration, days</td>
<td>27.6</td>
</tr>
<tr>
<td>imported</td>
<td>26.3</td>
</tr>
<tr>
<td>domestic</td>
<td>18.2</td>
</tr>
<tr>
<td>Product inflation, ann %</td>
<td>0.86</td>
</tr>
<tr>
<td>imported</td>
<td>2.19</td>
</tr>
<tr>
<td>domestic</td>
<td>-1.53</td>
</tr>
</tbody>
</table>
Price levels before/after a stockout

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

**Price levels before/after a stockout**

(a) All price changes

(b) Domestic versus Imported Goods
Do retailers pass through rising costs to prices or to shortages?

- Inventories depend on the cost of supplying/replacing goods (also interact with price decisions)

- Model of monopolistic firm with inventories (build on Kryvtsov and Midrigan, 2013)
  - Inventories help firm to manage incidence of stockouts
  - Convex cost of adjusting inventories
Do retailers pass through rising costs to prices or to shortages?

- Inventories depend on the cost of supplying/replacing goods (also interact with price decisions)

- Model of monopolistic firm with inventories (build on Kryvtsov and Midrigan, 2013)
  - Inventories help firm to manage incidence of stockouts
  - Convex cost of adjusting inventories

- Model predicts:
  - Probability of temporary stockout given the firm’s price, and current/future replacement cost
  - Past stockouts raise replacement costs

- Easy to aggregate to sector level and eliminate persistent component of replacement costs

- Estimate using weekly panel of TOOS and price data, obtain innovations to replacement costs
Responses to +1std sector real replacement cost impulse

- Retailers pass cost shock through to both prices and stockouts
- Endogenous stockouts $\rightarrow$ Inflation responses are relatively more volatile but less persistent
Responses to +1std sector real replacement cost impulse

- Retailers pass cost shock through to both prices and stockouts
- **Endogenous stockouts** → Inflation responses are relatively more volatile but less persistent
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
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

- Are product shortages associated with inflation?
  Yes, product shortages have economically significant inflationary effects, within 1 to 3 months

- Do inflationary effects reflect supply-chain disruptions?
  Yes, effects are larger and more persistent for imported goods and import-intensive sectors

- Do retailers pass through rising costs to prices or to shortages?
  Retailers pass through heightened replacement cost to both prices and stockouts
THANK YOU
U.S. Census Small Business Pulse Survey
Global Supply Chain Pressures Index (Benigno et al. 2022)