Supply Chain Constraints and Inflation

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Inflation

US Personal Consumption Expenditures (PCE) Inflation

Source: Bureau of Economic Analysis & authors’ calculations.
Everyone is Talking about Supply Chains

Gita Gopinath in the IMF’s World Economic Outlook:

*Pandemic outbreaks in critical links of global supply chains have resulted in longer-than-expected supply disruptions, further feeding inflation in many countries.*

Jerome Powell in The New York Times:

*The world’s top central bankers acknowledged that inflation...could remain elevated for some time...[Jerome Powell] noted that while demand was strong in the United States, factory shutdowns and shipping problems were holding back supply, weighing on the economy and pushing inflation above the Fed’s goal...“[i]t is also frustrating to see the bottlenecks and supply chain problems not getting better...We see that continuing into next year, probably, and holding inflation up longer than we had thought,” Mr. Powell said.*
Constraints in Global Supply Chains

1. Do supply chain constraints explain the surge of inflation?
   - We emphasize supply constraints for imported inputs:
     - Quantity restrictions on input supply (e.g., factory shutdowns).
     - Fixed capacity of logistics infrastructure (e.g., ports).
   - Binding constraints may produce non-linear outcomes.
     Occasionally binding constraints present technical challenges.
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2. What role for shocks to demand vs. supply in explaining inflation?
   - Strong US demand growth, biased toward goods.
   - Demand interacts with capacity constraints:
     - Rising demand may exhaust existing capacity.
     - But, negative supply-side shocks may have reduced capacity.
     - With endogenous capacity, negative demand shocks may trigger capacity disinvestment, which tightens future constraints (e.g., chips).
Emphasis on Imported Inputs

Import Price Inflation

- Total
- Industrial Materials & Supplies (excluding fuels)
- Consumer Goods (excluding autos)

Source: Bureau of Labor Statistics & authors’ calculations.
Model Overview

Small Open Economy, New Keynesian model with:

- Standard features: unit continuum of monopolistically competitive firms, price rigidities, complete financial markets, etc.

- New standard features:
  - Dollar (dominant) currency pricing. [Gopinath et al. (2020)]
  - Imported inputs + input-output linkages in multisector model.

- Brand new features: occasionally binding constraints.
  - Capacity constraints for foreign firms ("micro constraint").
    - Upper bound on maximal quantity supplied by the foreign firm.
    - Foreign producers internalize this constraint when setting prices.
    - Constraint may be time-varying: either due to exogenous shocks (e.g., COVID shutdown), or endogenous capacity investment.
  - Aggregate import constraint ("macro constraint").
    - Upper bound on total import volume (as in fixed port capacity).
    - This constraint is not internalized by individual firms.
    - We treat this constraint as exogenous, possibly time varying.
Foreign Firms

Firm $\omega$ sets $P_{Ft}(\omega)$ in Dollars to solve:

$$\max_{\{P_{Ft}(\omega)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \frac{S_{0,t}^*}{P_t^* E_t} \left[ (P_{Ft}(\omega) - E_t MC_t^*) Y_t^*(\omega) - \Phi(P_{Ft-1}(\omega), P_{Ft}(\omega)) \right]$$

s.t. $Y_t^*(\omega) = \left( \frac{P_{Ft}(\omega)}{P_{Ft}} \right)^{-\epsilon} Y_t^*$

and $Y_t^*(\omega) \leq \bar{Y}_t^*$

with $\Phi(P_{Ft-1}(\omega), P_{Ft}(\omega)) \equiv \frac{\phi}{2} \left( \frac{P_{Ft}(\omega)}{P_{Ft-1}(\omega)} - 1 \right)^2 P_{Ft} Y_t^*$. 
Pricing in Symmetric Equilibrium

Optimal Pricing:

\[ 0 = 1 - \epsilon \left( 1 - \frac{E_t(MC^*_t + \mu^*_t)}{P_{Ft}} \right) - \phi (\Pi_{Ft} - 1) \Pi_{Ft} \]

\[ + E_t \left[ S^*_{t,t+1} \left( \frac{E_t P^*_t}{E_t+1 P^*_{t+1}} \right) \phi (\Pi_{Ft+1} - 1) \Pi^2_{Ft+1} \frac{Y^*_{t+1}}{Y^*_t} \right] \]

with \( \Pi_{Ft} \equiv P_{Ft}/P_{F,t-1} \).

Complementary Slackness Condition:

\[ \mu^*_t \left[ \bar{Y}^*_t - Y^*_t \right] = 0 \]

plus \( \mu^*_t \geq 0 \) and \( Y^*_t \leq \bar{Y}^*_t \).

Slack constraint \( \Rightarrow \mu^*_t = 0 \Rightarrow \) import price Phillips Curve holds.

Binding constraint \( \Rightarrow Y^*_t = \bar{Y}^*_t \Rightarrow \) price determined by demand.
Aggregate Import Constraint

\[ M_{Ft} \equiv \int_{0}^{1} M_{Ft}(\omega) d\omega \leq \bar{M}_t, \]

where \( M_{Ft}(\omega) \) is use of composite imported input by firm \( \omega \).

This is an aggregate constraint, so firms do not internalize it. Firms compete to split total demand among themselves.

When this constraint binds:

\[ \bar{M}_t = (1 - \xi) (P_{Ft})^{-\eta} (P_{Mt})^{\eta} M_t \]

Since \( P_{Ft} \) is sticky, then adjustment is shifted onto \( P_{Mt} \) and \( M_t \).
Comparing the Constraints

**Case 1**: micro constraint binds, macro constraint is slack.
\[ \bar{M}_t \to \infty \text{ and } \bar{Y}_t^* \text{ is sufficiently low.} \]

**Case 2**: micro constraint is slack, macro constraint binds.
\[ \bar{Y}_t^* \to \infty \text{ and } \bar{M}_t \text{ is sufficiently low.} \]

Examine model responses to demand shock (discount rate shock).

We solve the model using OccBin [Guerrieri and Iacoviello (2015)].

- The perturbation-type solution is piecewise linear, so captures potential non-linearities in responses.
- Impulse response functions differ depending on whether shock hits in constrained or unconstrained equilibrium.
#1: Macro constraint binds ⇒ ex. rate appreciation reduces $\pi_{Ft}$, like in the unconstrained equilibrium.

#2: Micro constraint binds ⇒ $\pi_{Ft}$ jumps upwards, as in data.

#3: Consumer price inflation ($\pi_t$) is higher in constrained equilibria, but similar for both constraints.
Two Sector Model

Recall: goods price inflation accelerates, with import price inflation. Consumer demand shifted toward goods during the pandemic. Goods production uses imported inputs intensively, relative to services.

Two sector model is analog to one sector model:

- Input-output linkages across sectors in production.
- We impose constraints for goods production \((g)\).
- Focus on micro constraint: \(Y^*_t(g, \omega) \leq \bar{Y}^*_t(g)\).

Consumer demand for sector \(s\): \(C_t(s) = \zeta_t(s) \left(\frac{P_t(s)}{P_t}\right)^{-\psi} C_t\).

Examine goods-biased demand shock – i.e., an increase in \(\zeta_t(s)\).
Consumer Expenditure Shares

Source: Bureau of Economic Analysis & authors’ calculations.
Consumer Price Inflation

(a) No Binding Constraints

(b) Binding Micro Constraint

Slack constraint $\Rightarrow$ inflation rises, less in goods than services.

Binding constraint $\Rightarrow$ more inflation, and more in goods than services.
Import Price Inflation for Goods

(a) Import Price Inflation: $\pi_{Ft}(g)$

(b) Terms of Trade: $P_{Ft}(g)/P_t(g)$
Inflation Accounting

\[ \pi_{Ht}(g) = \left( \frac{\epsilon - 1}{\phi} \right) \sum_{r=0}^{\infty} \beta^r E_t \widehat{rmc}_{t+r}(g) \]

with \( RMC_t(g) \equiv \frac{1}{Z_t(g)} \left( \frac{W_t}{P_t(g)} \right)^{1-\alpha(g)} \left( \frac{P_{Mt}(g)}{P_t(g)} \right)^{\alpha(g)} \)

(a) No Binding Constraints

(b) Binding Micro Constraint
On the Agenda

1. Endogenous, time-varying capacity choices by firms.
2. Domestic capacity constraints.
3. Heterogeneity in firm-level constraints.
4. Full quantitative analysis of the role of supply chain and demand shocks in the pandemic.
Takeaways


2. With micro constraints for foreign goods production, a goods-biased demand shock yields:
   ▶ Sharp rise in import price inflation,
   ▶ An increase in total consumer price inflation,
   ▶ More inflation for goods than services.

**Binding constraints may help explain recent \( \pi \) outcomes.**


