Supply Chain Constraints and Inflation

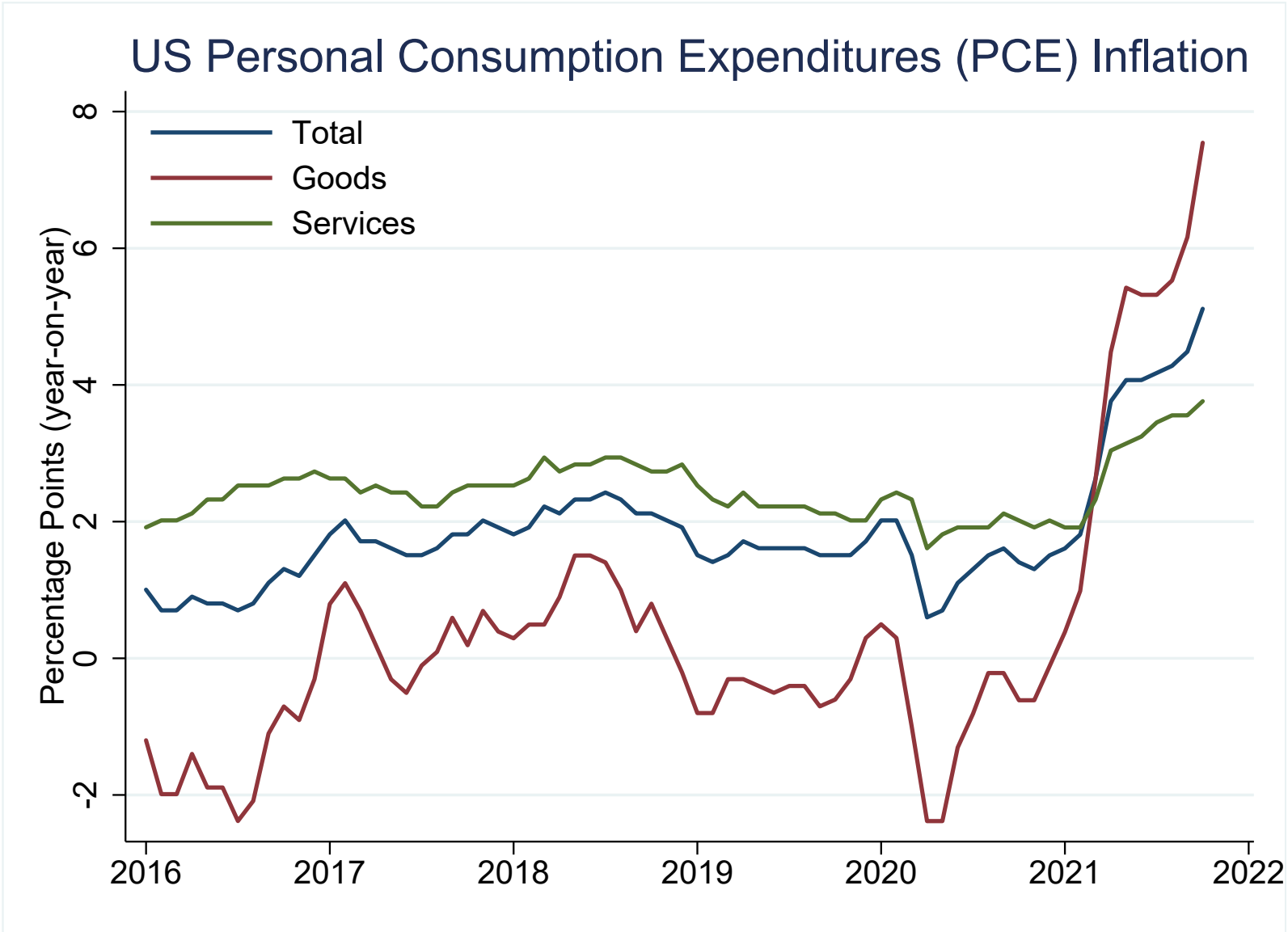
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December 10, 2021

NBER Conference on The Rise of Global Supply Chains

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:

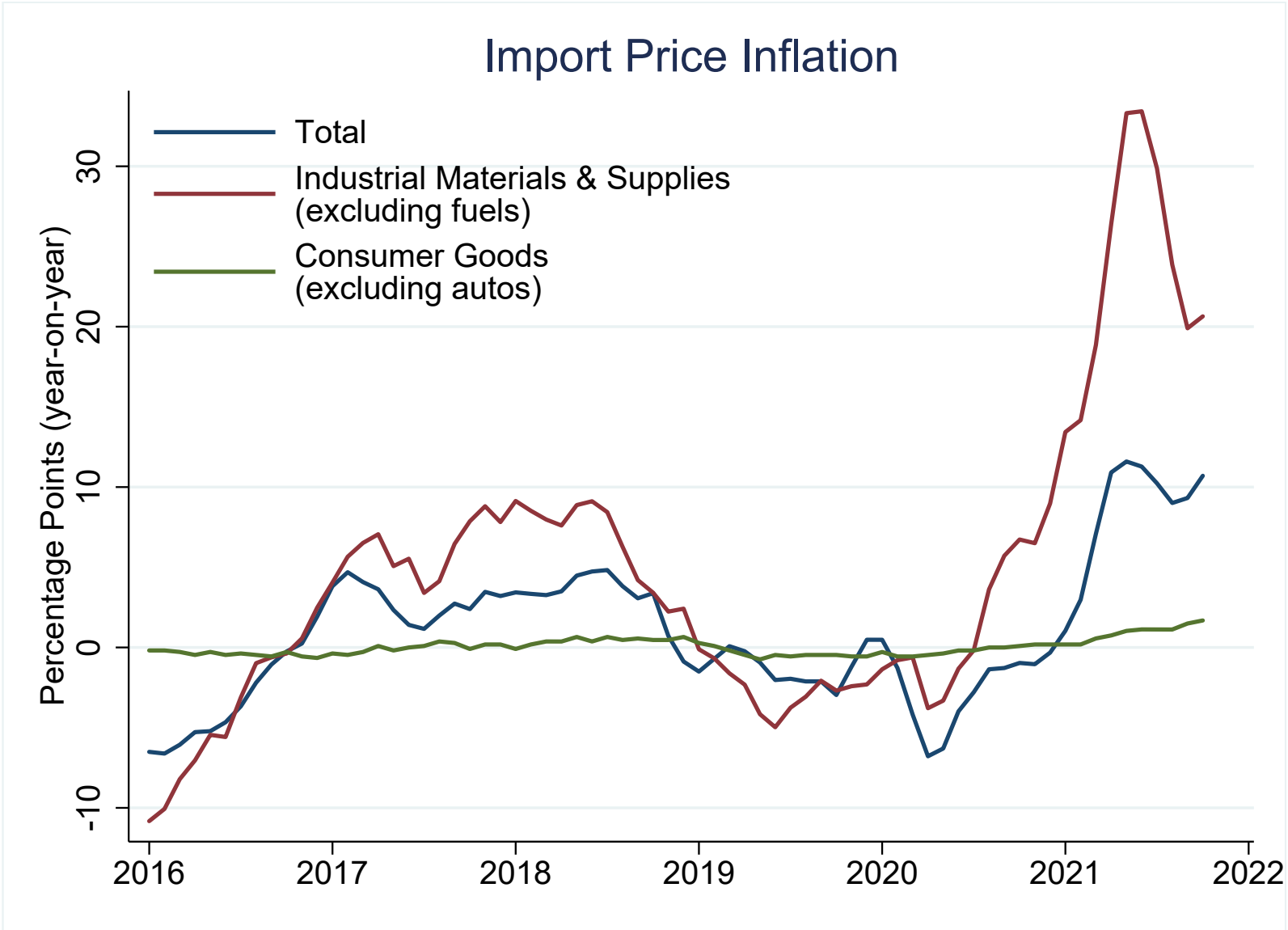
> *The world's top central bankers acknowledged that inflation...could remain elevated for some time...[Jerome Powell] noted that while demand was strong in the United States,* **factory shutdowns and shipping problems were holding back supply**, *weighing on the economy and* **pushing inflation above 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.

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



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

$$\max_{\{P_{Ft}(\omega)\}} \mathbf{E}_0 \sum_{t=0}^{\infty} \frac{S^*_{0,t}}{P^*_t E_t} \left[\left(P_{Ft}(\omega) - E_t MC^*_t \right) Y^*_t(\omega) - \Phi(P_{Ft-1}(\omega), P_{Ft}(\omega)) \right]$$

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

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

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:

$$0 = 1 - \epsilon\left(1 - \frac{E_t(MC_t^* + \mu_t^*)}{P_{Ft}}\right) - \phi\left(\Pi_{Ft} - 1\right)\Pi_{Ft}$$
$$+ \mathbf{E}_t\left[S_{t,t+1}^*\left(\frac{E_t P_t^*}{E_{t+1}P_{t+1}^*}\right)\phi\left(\Pi_{Ft+1} - 1\right)\Pi_{Ft+1}^2\frac{Y_{t+1}^*}{Y_t^*}\right]$$

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 ω.

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.
$\bar{M}_t \to \infty$ and $\bar{Y}_t^*$ is sufficiently low.

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

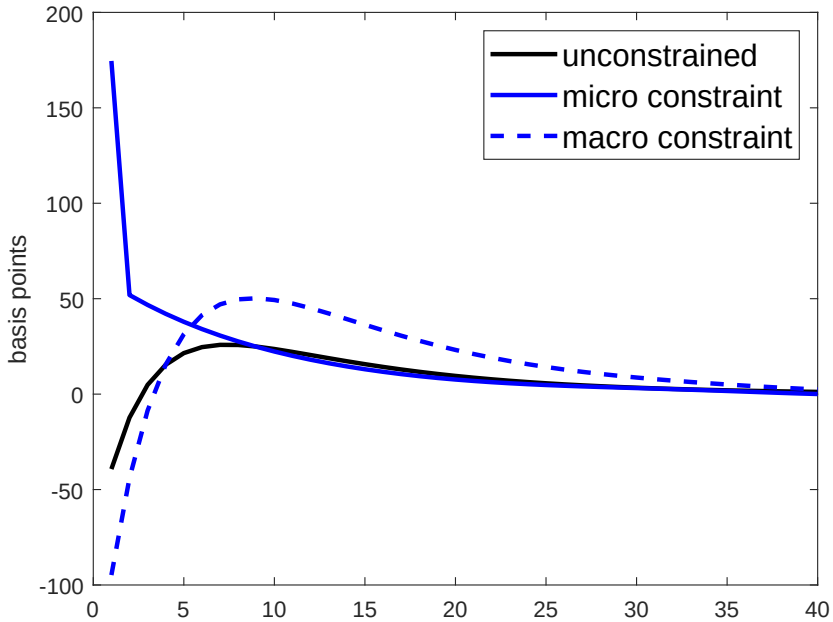
Examine model responses to demand shock (discount rate shock).

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

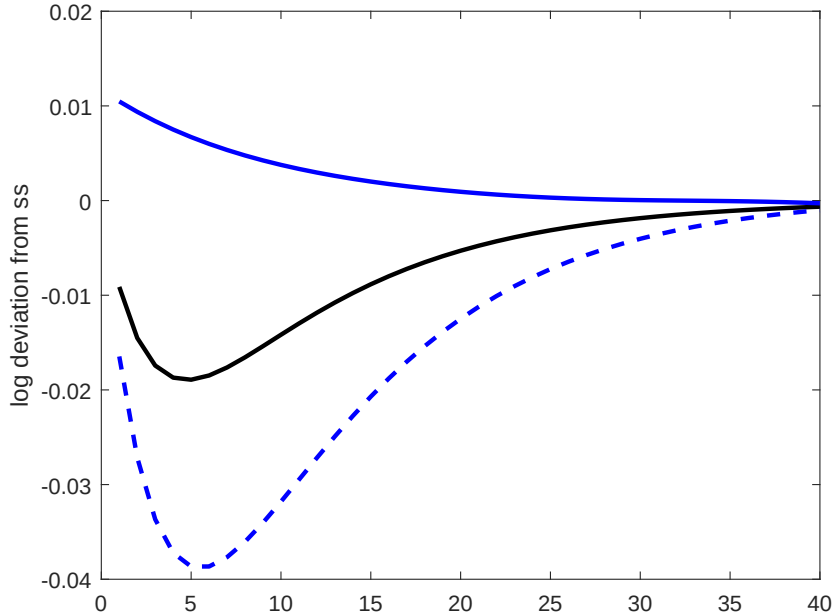
- The perturbation-type solution is piecewise linear, so captures potential non-linearities in responses.
- Impulse response functions differ depending on whether shock hits in constrained or unconstrained equilibrium.

Import Prices under Alternative Constraints

(a) Import Price Inflation: π_{Ft}



(b) Terms of Trade: P_{Ft}/P_t



#1: Macro constraint binds $\Rightarrow$ ex. rate appreciation reduces π_{Ft}, like in the unconstrained equilibrium.

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

#3: Consumer price inflation (π_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.

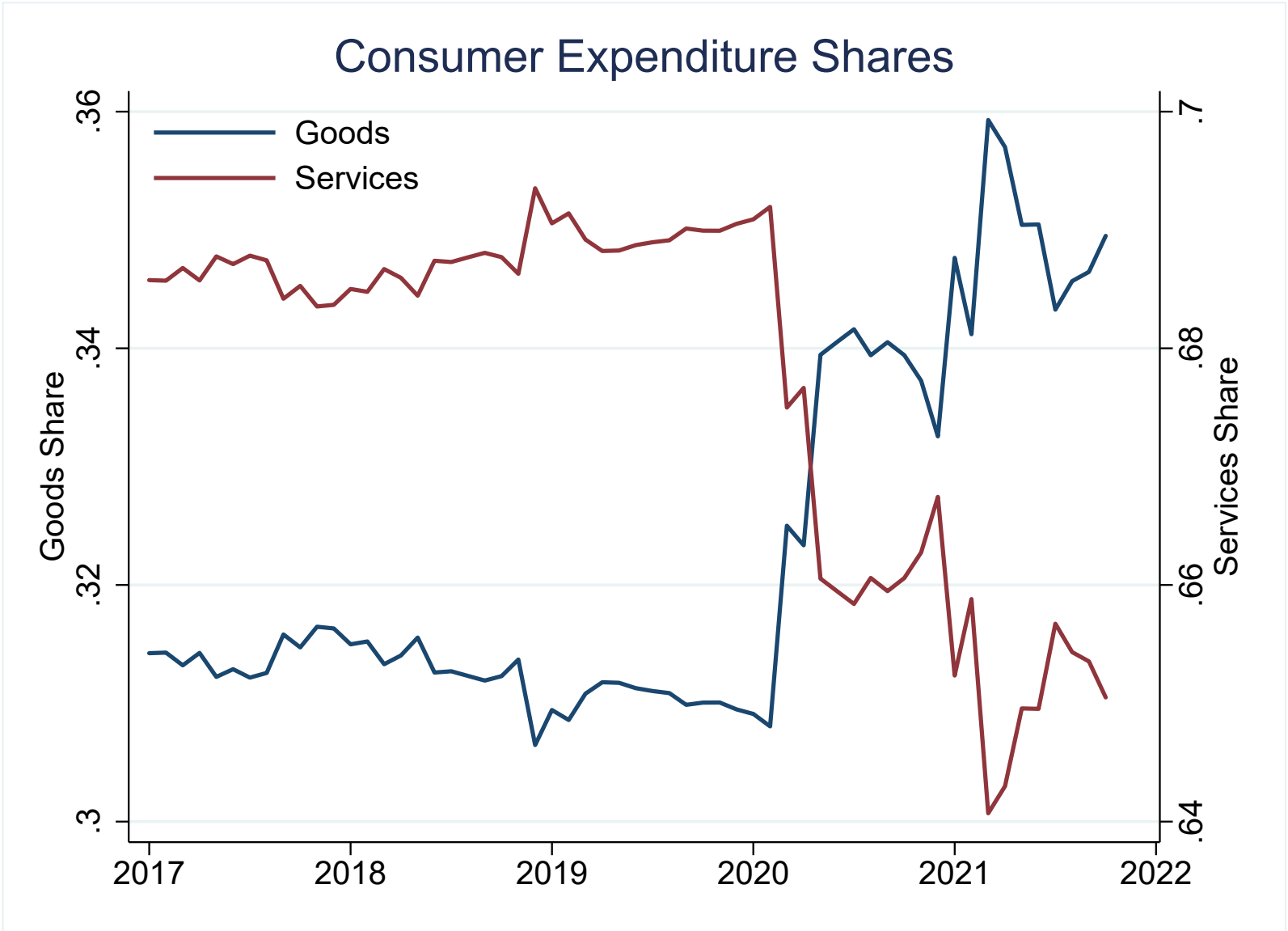
Two sector model is analog to one sector model:

- 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: $C_t(s) = \zeta_t(s)\left(\frac{P_t(s)}{P_t}\right)^{-\vartheta} C_t$.

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

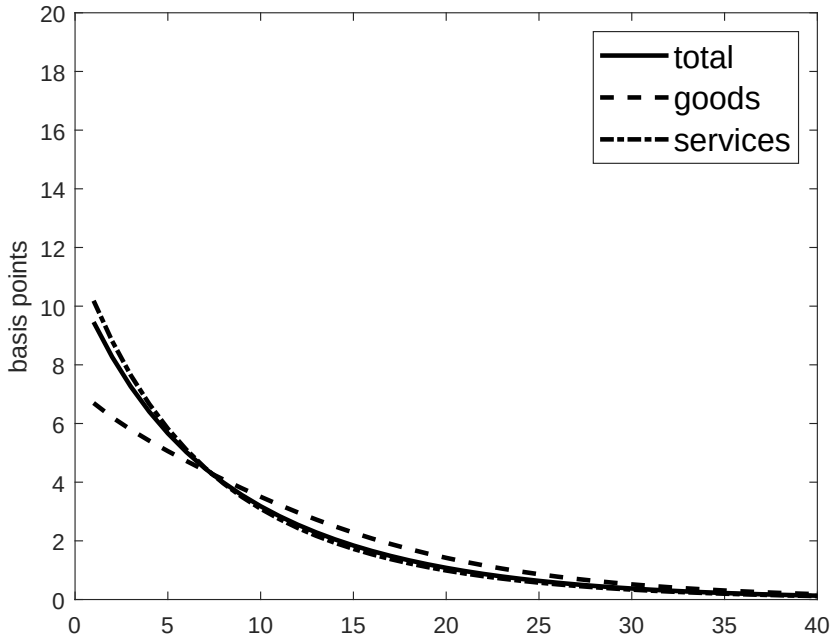
Consumer Expenditure Shares



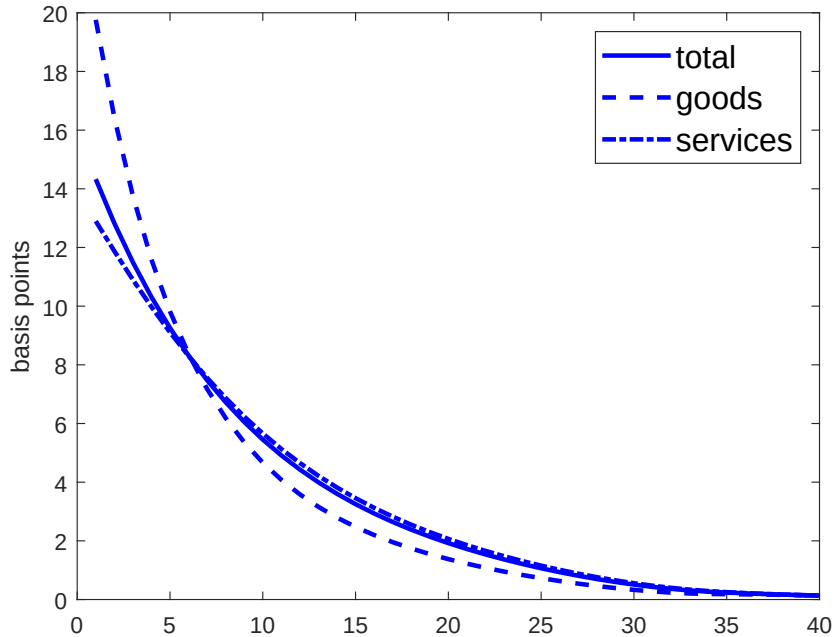
Source: Bureau of Economic Analysis & authors' calculations.

Consumer Price Inflation

(a) No Binding Constraints



(b) Binding Micro Constraint

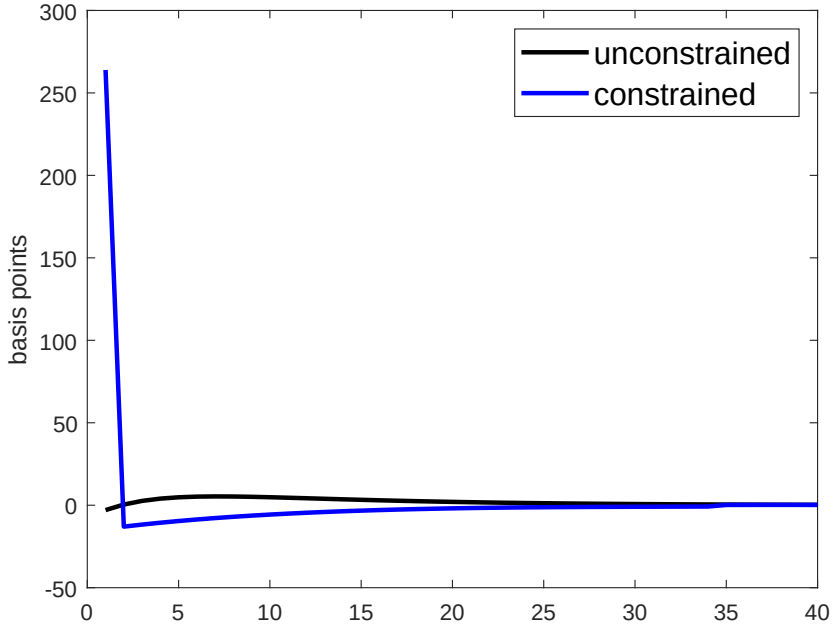


Slack constraint $\Rightarrow$ inflation rises, less in goods than services.

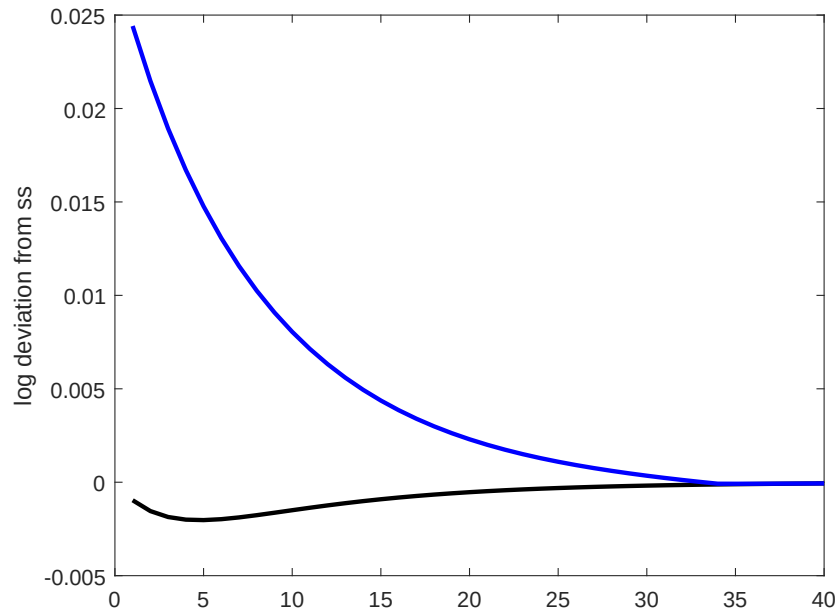
Binding constraint $\Rightarrow$ more inflation, more in goods than services.

Import Price Inflation for Goods

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



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

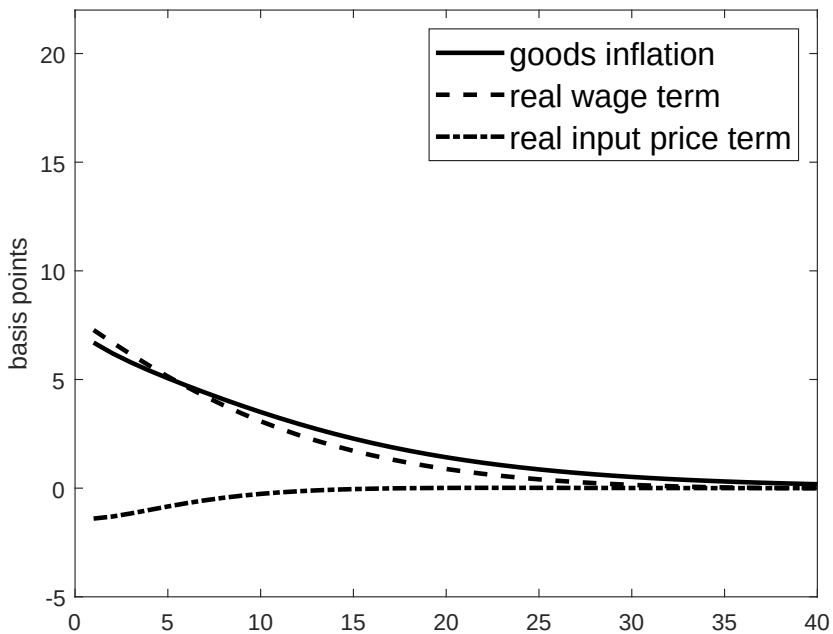


Inflation Accounting

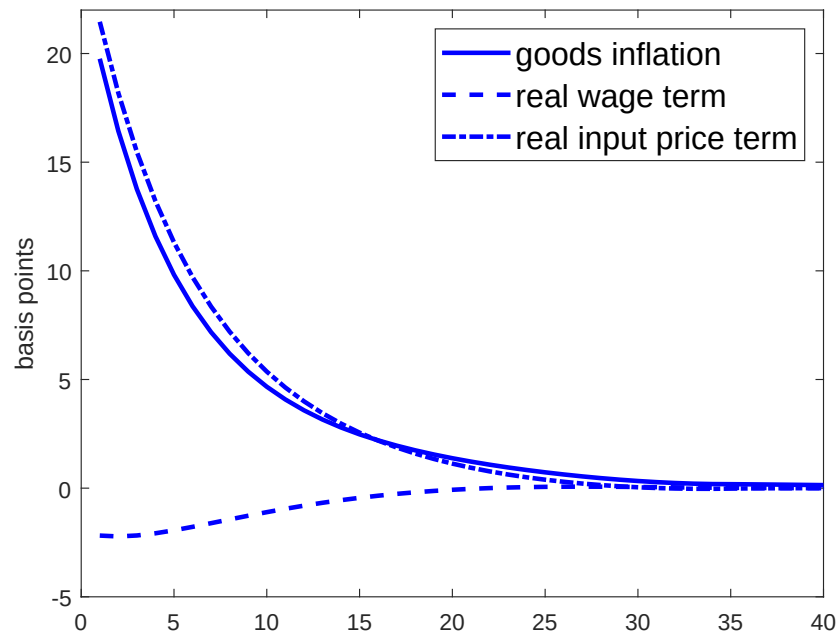
$$\pi_{Ht}(g) = \left(\frac{\epsilon - 1}{\phi}\right) \sum_{r=0}^{\infty} \beta^r E_t \widehat{rmc}_{t+r}(g)$$

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

(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

1. Micro (firm-level) constraints yield import price inflation.
   Macro (aggregate) import constraints yield import price deflation.

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 π outcomes.

References I

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