Monetary Policy: Supply Shocks in Network Economies

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How should monetary policy be conducted when:

- the economy consists of multiple, heterogeneous sectors
- there is a complex network of intermediate good trade across sectors
- heterogeneous productivity (supply) shocks hitting these sectors
Supply Shocks

Source: U.S. Energy Information Administration
fred.stlouisfed.org

Dollars per Barrel


Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma
Crude Oil Prices: Brent - Europe
Supply Chain disruptions are important

In the last week, did this business have domestic supplier delays? (percentage saying yes)

- Manufacturing
- Construction
- Retail Trade
- Wholesale Trade
- Accommodation and Food Services
- Other Services (Except Public Administration)
- Administrative and Support Services
- Utilities
- Health Care and Social Assistance
- Arts, Entertainment, and Recreation
- Real Estate and Rental and Leasing
- Information
- Transportation and Warehousing
- Mining, Quarrying, and Oil and Gas Extraction
- Professional, Scientific, and Technical Services
- Educational Services
- Finance and Insurance

Sources: U.S. Census Bureau; CEA Calculations.

Council of Economic Advisors Report; June 17, 2021
Overview: the standard model

- In the standard NK model, in response to productivity shocks:
  - optimal for monetary policy to stabilize the aggregate price level
  - why? price stability preserves productive efficiency and implements the first best
  - price stability minimizes both inflation and the “output gap”
- target is straightforward in the model: aggregate price level = average price across firms
Monetary policy with supply chains?

- does it remain optimal to stabilize an aggregate price level?

- if so, what is the appropriate aggregate price index?
  - overall measures of consumer prices? e.g. CPI, PCE
  - measures of producer prices? e.g. PPI
  - indices that exclude food and energy categories? e.g. Core measures
  - how should we account for changes in the relative size of sectors? e.g. healthcare and services
Multi-Sector NK Models


- multi-sector: Mankiw and Reis (2003), Eusepi, Hobijn, Tambalotti (2011)


- key lessons from this literature:
  - stabilize “sticky” sectors
  - stabilize upstream sectors
  - intermediate good trade can amplify frictions
Multi-Sector NK Models

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Multi-Sector Horizontal Economy

**Figure:** Horizontal Economy
Optimal monetary policy: stabilize stickier sectors

why?

- if only one sector is sticky, it is optimal to stabilize price of that one sector (Aoki, 2001)
- such a policy leads to no price dispersion in the sticky sector, and all other sectors adjust flexibly
- in general, stickier sectors: greater potential for relative pricing errors and greater price dispersion

principle of “sticky-price stabilization,” first proposed by Goodfriend and King (1997)

But what about supply chains?

- the horizontal economy has no input-output linkages

- how does the input-output structure of the economy affect optimal monetary policy?

- the following results are based on my paper:

  “Optimal Monetary Policy in Production Networks” with Alireza Tahbaz-Salehi
Baseline Framework

- static environment

- production: $n$ sectors indexed by $i \in I \equiv \{1, \ldots, n\}$
  - continuum of identical firms within a sector, indexed by $k \in [0, 1]$
  - firms produce differentiated goods $\rightarrow$ monopolistic competitors
Technology

- production function of firm $k$ in sector $i$
  \[ y_{ik} = z_i e^{\theta_i} \prod_{j \in I} x_{ij,k} \]

- vector of sectoral productivity shocks
  \[ z = (z_1, \ldots, z_n) \]

- input-output matrix
  \[ A = [a_{ij}] \]
CES Aggregation and Preferences

- for every sector $i \in I$, CES aggregator firm

$$y_i = \left( \int_0^1 y_{ik}^{\frac{\theta_i-1}{\theta_i}} dk \right)^{\frac{\theta_i}{\theta_i-1}}$$

- representative household: consumes sectoral goods, supplies labor

$$U(C) - V(L)$$

$$C = C(c_1, \ldots, c_n)$$
Nominal Rigidity = Informational Friction

- firm managers make their nominal pricing decision under incomplete information
- managers face uncertainty over sectoral supply shocks

\[ z = (z_1, \ldots, z_n) \]

- firm manager in sector \( i \) is either “inattentive” or “attentive” to \( z \)
  - learns \( z \) perfectly with prob \( \phi_i \)
  - does not learn \( z \) with prob \( 1 - \phi_i \)

- \( \phi_i \in [0, 1] \) is the degree of price flexibility of industry \( i \)
  - \( \phi_i = 1 \) is full price flexibility
Consider first the Flexible-Price economy

- for a moment abstract from nominal rigidities:

\[ \phi_i = 1, \quad \forall i \in I \]

- under flexible prices, we have the typical input-output network model:

  - efficient economies: Long and Plosser (1983), Acemoglu et al (2012), Baqae and Farhi (2019), ...
  - markups and misallocation: Jones (2013), Baqae and Farhi (2020), Bigio and La’O (2020), ...
Domar Weights = sales shares

- define the equilibrium Domar weight of sector $i$ as:

$$\lambda_i \equiv \frac{p_i y_i}{PC}$$

- Domar weights are equilibrium sales shares of GDP
Hulten’s Theorem

Theorem

(Hulten, 1978) To a first-order approximation around efficiency, aggregate TFP satisfies

$$d \log TFP \approx \sum_{i \in N} \lambda_i d \log z_i$$

- $\lambda_i$: sufficient statistic for the first-order effect of a sectoral productivity shock on aggregate TFP
- with Cobb-Douglas technology, this is both exact and global:

$$\log TFP = \sum_{i \in N} \lambda_i \log z_i$$

- robust finding that Domar weight = sectoral “importance”
Consider now the full model with sticky prices
Our Main Result

Theorem

(La’O and Tahbaz-Salehi, 2022) The optimal monetary policy is a price index stabilization policy:

\[
\sum_{i \in I} \psi^*_i \log p_i = 0 \quad \text{with} \quad \sum_{i \in I} \psi^*_i = 1,
\]

with optimal weights \((\psi^*_1, \ldots, \psi^*_n)\) that satisfy:

- \(\psi^*_i\) is increasing in \(\lambda_i\) (Domar weight)
- \(\psi^*_i\) is decreasing in \(\phi_i\) (price flexibility)
General principles for monetary policy in production networks

- optimal monetary policy stabilizes an aggregate price index

- the optimal price index places greater weight on:
  - larger, more upstream sectors as measured by their Domar weights
  - stickier sectors

- synthesis and generalization of the main lessons from the two previous sets of literature
  - see also Rubbo (2022) for how network flattens the Phillips curve
Quantitative Illustration

- we calibrate the model:
  - BEA US input-output tables

- we find modest welfare improvements from adopting the optimal policy

- optimal price index:
  - greater weight on service sectors, healthcare, and some manufacturing
  - less weight on oil & gas, energy, and food (because these are fairly flexible)
Optimal Price Index

- Farms
- Forestry and fishing
- Oil and gas extraction
- Mining, except oil and gas
- Support activities for mining
- Utilities
- Construction
- Food, beverages, tobacco
- Textile mills
- Apparel and leather
- Paper products
- Primary metal products
- Electrical equipment, appliances
- Motor vehicles
- Fabricated metal products
- Machinery
- Computers and electronics
- Chemical products
- Petroleum and coal products
- Nonmetallic mineral products
- Primary metals
- Fabricated metal products
- Computers and electronics
- Wholesalers
- Retailers
- Motor vehicle and parts dealers
- Food and beverage stores
- General merchandise stores
- Legal services
- Administrative and support services
- Waste management services
- Health care services
- Hospitals
- Nursing and care facilities
- Amusement, gambling, recreation
- Accommodation

Optimal policy
Output-gap stabilization
Thank You!