Monetary Policy: Supply Shocks in Network Economies

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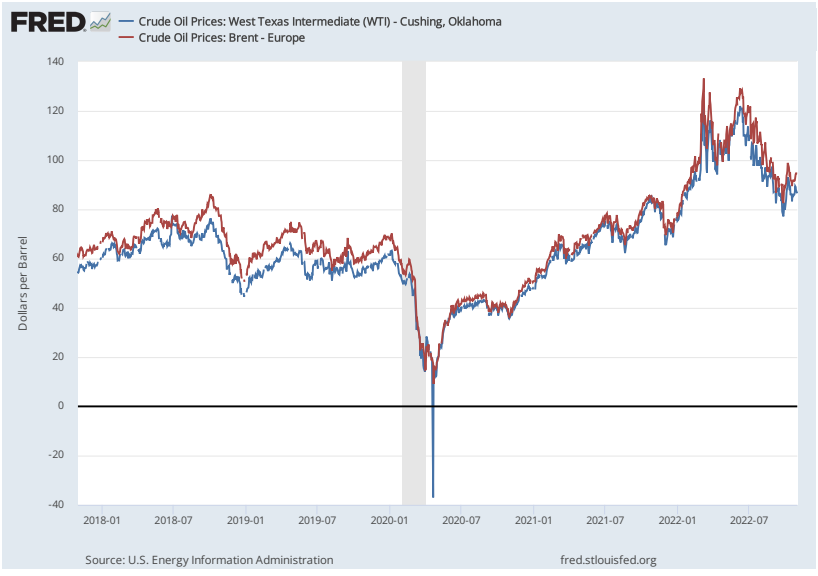
Monetary Policy and Supply Chains

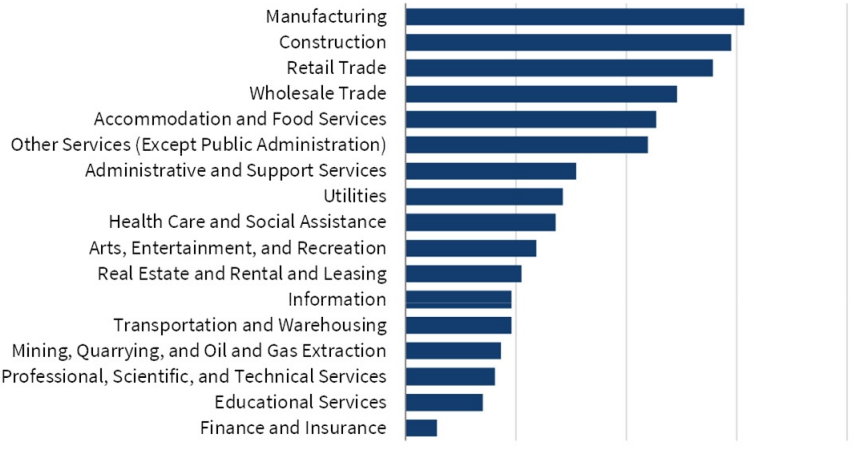
- How should monetary policy be conducted when:
  - the economy consists of multiple, heterogeneous sectors
  - there is a complex network of intermediate good trade across sectors
  - heterogeneous productivity (supply) shocks hitting these sectors

Supply Shocks



Supply Chain disruptions are important

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



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

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
  - "Divine Coincidence" Blanchard and Gali (2007)
  - 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

- two-sector: Erceg, Henderson, Levin (1999), Aoki (2001), Woodford (2003), Benigno (2004), Woodford (2010)
- multi-sector: Mankiw and Reis (2003), Eusepi, Hobijn, Tambalotti (2011)
- w/intermediate good trade: Basu (1995), Huang and Liu (2005)
- key lessons from this literature:
  - stabilize "sticky" sectors
  - stabilize upstream sectors
  - intermediate good trade can amplify frictions

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Multi-Sector Horizontal Economy

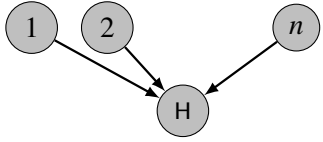


Figure: Horizontal Economy

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)
- later formalized in: Aoki (2001), Woodford (2003), Benigno (2004), Woodford (2010), Mankiw Reis (2003), Eusepi, Hobijn, Tambalotti (2011)

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

$$y_{ik} = z_i \ell_{ik}^{\alpha_i} \prod_{j \in I} x_{ij,k}^{a_{ij}}$$

- 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

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

$$C = \mathcal{C}(c_1, \ldots, c_n)$$

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 ϕ_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:

$$\phi_i = 1, \qquad \forall i \in I$$

- under flexible prices, we have the typical input-output network model:
  - efficient economies: Long and Plosser (1983), Acemoglu et al (2012), Baqaee and Farhi (2019), ...
  - markups and misallocation: Jones (2013), Baqaee 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

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

- λ_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:

$$\sum_{i \in I} \psi_i^* \log p_i = 0 \qquad \textit{with} \qquad \sum_{i \in I} \psi_i^* = 1,$$

with optimal weights $(\psi_1^*, \ldots, \psi_n^*)$ *that satisfy:*

- ψ_i^* *is increasing in* λ_i *(Domar weight)*
- ψ_i^* *is decreasing in* ϕ_i *(price flexibility)*

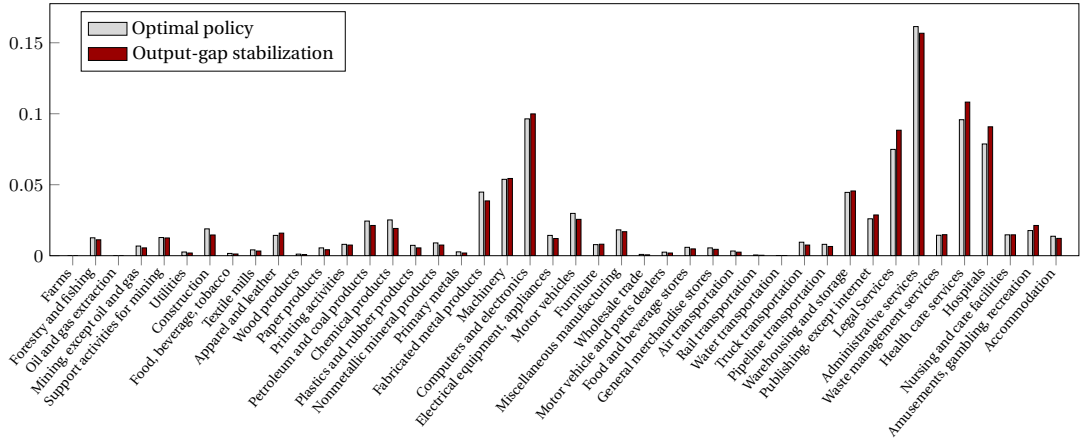
General principles for monetary policy in production networks

- 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
  - data on sectoral price stickiness (PPI): Pasten, Schoenle, and Weber (2019)
- 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



Thank You!