Production Networks and the Flattening of the Phillips Curve

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Motivation

The relationship between the slack in the economy or unemployment and inflation was a strong one 50 years ago ... and has gone away. (Jerome Powell, 2019)

- The Phillips curve has become flatter in recent decades. (Ball & Mazumder 2014, Kiley 2000, 2015)
- Implications for central banks ability to control and predict inflation.
- Potential explanations:
  1. Success of monetary policy in anchoring expectations (Bernanke, 2010),
  2. Credibility of the central bank (McLeay & Tenreyro, 2019),
  3. Global forces (Jordá et al., 2019),

- This paper proposes a novel explanation based on changes in the production network structure of the economy.
Has the structure of the U.S. network changed?

Figure: US Input-Output network in 1963. Manufacturing Services Other
Has the structure of the U.S. network changed? **YES**

**Figure:** US Input-Output network in 2017. **Manufacturing Services Other**
Contribution

Could a change in the U.S. production network account for the flattening of the Phillips curve?

- I combine a multi-sector New Keynesian model with production networks & historical data on input-output relations in the U.S.

Main findings:

1. Inflation dynamics depend on the network structure: generalized NK Phillips curve.
2. Change to production structure can account for a decrease in the slope of up to a quarter of total flattening.
3. Ignoring the network channel, i.e. allowing only for compositional changes, we would miss half of this change.

Mechanism

- Increase in the importance of sectors that change prices less often.
  \[\Rightarrow\] Aggregate degree of nominal rigidity in the economy increases.
Relationship to the Literature

1 Evidence and Explanations for Flattening of the Phillips Curve:
   - This paper: structural approach.

2 Multi-Sector Models with Production Networks:
   - This paper: two (endogenous) network statistics.

3 New Keynesian Models with Production Networks:
   - This paper: studies effects on Phillips curve.
The Model
Model Environment

1. A representative HH makes consumption and labor supply decisions.

2. Firms are within a Nested CES structure: Within sectors firms face monopolistic competition and prices are sticky a la Calvo.

3. The key: intermediate good production
   ⇒ Technology: an Extension of the Basic NK Model
Household

Household’s problem and budget constraint

\[
\max_{C_t, L_t, B_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\varphi}}{1+\varphi} \right]
\]

\[
P_tC_t + Q_tB_t = \sum_k W_{k,t}L_{k,t} + B_{t-1} + \sum_k \int D_{k,t}(i) di
\]

Total consumption

\[
C_t = \prod_{k=1}^{K} C^{\delta_k}_{k,t}
\]

and \(C_{k,t} = CES(C_{k,t}(i), \varepsilon_k)\). Imperfect labor mobility, \(L_t = CES(L_{k,t}, \nu)\).
Technology: an Extension of the Basic NK Model

Firm $i$ of sector $k$ produces with technology

$$Q_{k,t}(i) = L_{k,t}(i)^{1-\gamma_k} X_{k,t}(i)^{\gamma_k}$$

where

$$X_{k,t}(i) = \left( \prod_{j=1}^{K} X_{k,t}(i,j)^{\omega_{k,j}} \right)$$

Network ingredients:

- $X_{k,t}(i,j) = CES(X_{k,t}(i,j,h), \varepsilon_k)$: intermediate input use of firm $(k,i)$ from sector $j$.
- $\gamma_k$: intermediate input share.
- $\omega_{k,j}$: expenditure on sectoral intermediate goods.
Generalized Sectoral New Keynesian Phillips Curves

\[ \hat{\pi}_{k,t} = \beta E \hat{\pi}_{k,t+1} + \left( \frac{1 - \gamma_k}{1 + \gamma_k \varphi} \right) \Phi_{k}^{Std} \hat{y}_t + \Psi_{k,t} \]

\[ \Psi_{k,t} = \kappa_k \frac{\varphi(1 - \gamma_k)}{1 + \gamma_k \varphi} (\hat{\delta}_{k,t} + \hat{\Phi}_t^{NM}) + \kappa_k \frac{1 + \varphi}{1 + \gamma_k \varphi} (\gamma_k \hat{p}_t^k - \hat{p}_{k,t}) \]

- \( \Phi_{k}^{Std} = \kappa_k (\sigma + \varphi) \): slope standard NK model.
- \( \Psi_{k,t} \): endogenous term.
The Role of two Network Statistics

- Network Multiplier, $\Phi_{t}^{NM} = \frac{O_t}{Y_t}$: A measure of the importance of the network in this economy.

- Sectoral (Gross) Output share, $\delta_{k,t} = \frac{P_{k,t}Q_{k,t}}{P_tQ_t}$: A measure of the importance of the sector in the network (Katz, 1953).

- Both are endogenous and depend on (countercyclical) markups.
Aggregate Inflation Dynamics and Estimation Bias

Generalized Aggregate New Keynesian Phillips Curve

\[ \hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \tilde{\Phi}^{Std} \hat{y}_t + \Psi_t \]

Implications:

- \( \Psi_t \) depends on the network structure of the economy.
- \( \Psi_t \) introduces bias in estimate of slope of standard NKPC because correlated with \( \hat{y}_t \), i.e \( \text{Corr}(\hat{y}_t, \Psi_t) \neq 0 \).
- Flattening of PC either because of (i) decline in standard slope or (ii) change in bias.
How to Derive Evolution of Slope over time?

- **Identification strategy**: Changes in the network structure will be reflected as changes to the technology of firms.

- Match parameters of the production function in the model to changes in expenditure shares in the data.

- Use historical U.S. data on Input-Output linkages from 1963 - 2017 to calibrate technology parameters.
  - Intermediate input share, $\gamma_k$,
  - Expenditure on sectoral intermediate goods, $\omega_{k,j}$
  - Consumption shares: $\vartheta_k$.

- Simulate data from model for series of shocks and estimate slope of Phillips curve.
Change to Network in U.S.
Change in centrality $\delta_{k,t}$ from 1963 to 2017
No trend in network multiplier over time
Findings and Counterfactuals
Decrease of model implied slope

Figure: The shaded regions report point-wise 68% and 90% credible sets.
Mechanism and Importance of Network

- Main channel: Increase importance of more rigid sectors.

- Network channel is important:
  1. Importance of sectors measured by centrality.
  2. Compositional changes in consumption shares capture only half of the flattening.
Conclusion

1. Do inflation dynamics depend on the network structure of the economy?
   - Yes, a NK model with production networks predicts
     - a generalized NK Phillips curve that depends on two network statistics,
     - the importance of sectors is measured by its (gross) output share.

2. Could a change in the U.S. production network account for the flattening of the Phillips curve?
   - Yes, structural transformation in the network structure can explain a flattening of about 15%.
   - Other dimension of production chains potentially also contribute:
     (i) global value chains (ii) rise in markups.

⇒ Accounting for production networks has important implications on inflation dynamics.
Appendix
Increase in Aggregate Degree of Rigidity

Average Degree of Nominal Rigidity

Aggregate Calvo Parameter ($\theta$)

Consumption share weighted, $\theta_k$

Date

Larger Increase in centrality weighted Rigidity

Average Degree of Nominal Rigidity

Aggregate Calvo Parameter ($\theta$)

- Consumption share weighted, $\psi_k$
- Output share weighted, $\delta_k$

Date:
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010
- 2020
Channel: Role of Network

Counterfactual: No change in consumption shares from 1963