Chopping the Onion: Input-Output Networks and Inflation Dynamics

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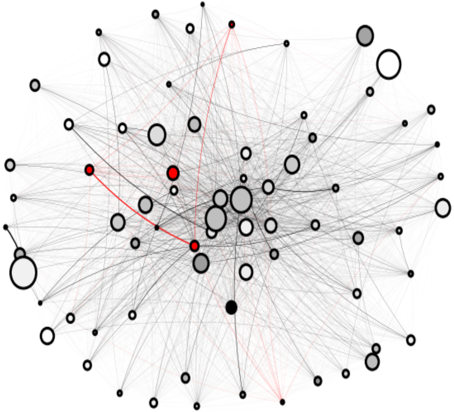
The onion view of inflation

- A popular way to analyze, and forecast, inflation dynamics is to consider inflation in the various sectors—food & energy, core goods, core services—and to assume that inflation in each sector evolves *independently* from one another, except for a *common component* (monetary policy, aggregate shocks)
- This view is embedded in current econometrics practice, eg Reis and Watson 2010, Stock and Watson 2016, New York Fed's MCT
- ... and in policy, eg Williams, 2022: the layers of the *onion*

Chopping the onion

- Recent literature studying inflation using networks (LaO & Tahbaz-Salehi, 2022; Rubbo, 2023; Afrouzi and Bhattarai, 2023) suggests that this view may not be entirely correct
- **The layers of the onion are interconnected via the I/O network of production**
- The interaction of heterogeneity in stickiness and the I/O network is key in order to understand 1) how changes in prices in some sectors transmit to other sectors via changes in marginal costs, and 2) the inflation-output tradeoffs induced by these shocks
- This view of inflation may be particularly relevant for studying the propagation of sector specific cost-push shocks, such as **a) tariffs, b) energy, c) pandemic, d) green transition, ...**



One presentation, $1 + \epsilon$ papers

- "Is the Green Transition Inflationary?"
- "A Network-Based Time Series Model for Inflation"

“Is the Green Transition Inflationary?”

Question

- Will the *green transition* (**taxes on polluting industries**) result in higher inflation? (Schnabel, 2022)

Answer from existing literature: No!

- **Theoretical**
  - **Olovsson and Vestin (2023)** use simple two-sector NK model to study the tradeoffs faced by monetary policymakers during the green transition
  - Bartocci et al. (2022) two-country DSGE with an energy sector and show that an increase in carbon tax dampens output; Ferrari and Nispi Landi (2022) point to importance of expectations on whether taxes are inflationary or not; 2022 WEO Ch 3: "**Climate policies have a limited impact on output and inflation and thus do not present a significant challenge for central banks**."
  - *Normative*: Nakov and Thomas (2023) investigate the normative question of whether central banks should fight climate change. Ferrari and Pagliari (2021) and Airaudo et al. (2023) consider optimal policy under the the green transition in the world economy and in a small open economy, respectively.

- **Empirical**
  - Känzig (2022) finds *significant effects of carbon tax on inflation*, while Konradt and Weder di Mauro (2021) find none

The Aoki (2001) consensus

- In the **two-sector** models used so far in the literature the "*Aoki* (2001) *consensus*" prevails
  - The carbon tax may have an effect on headline inflation, but its effect on core inflation is muted since the (*direct*) share of (dirty) energy as an input for the economy is relatively *small*
  - Hence policymakers should ignore it
- We show that accounting for the network reverses this conclusions

Our answer to Schnabel's question (analytical)

- **It depends on the interaction between the I/O network and stickiness**

- The **green transition** does not force monetary policymakers to tolerate higher inflation, but can generate a **tradeoff** (inflation vs. output gap), whose size depends on the interaction of **relative stickiness** and the **I/O network**

- If *prices in sectors that are (directly or indirectly) affected by the tax are more flexible relative to prices in the rest of the economy*, the adjustment in relative prices requires either **inflation**, if the gap is closed, or a **recession** to force down prices in the rest of the economy

Our answer (quantitative): Yes, Schnabel is right

$\sim$ 70-*sector* calibrated *network* model

- The carbon tax **propagates** through the I/O matrix
- Even if (dirty) energy is not a major input for the economy as a whole, it is an important input for some sectors which are *central* to the rest of the economy

- A gradual increase in carbon taxes from \$0 to \$100 would generate a **sizable tradeoff**
  - *Core inflation would be 50 to 100 bps higher than target for $\approx$ 10 years* if policy closes the output gap
  - *Inflation can only stabilized at a cost of a sizable contraction in economic activity*

Analytical results

Simple New Keynesian I/O model

- $c_t = y_t$ (no capital) and $w_t = y_t$ (households' utility depends on $\ln c_t - bL_t$)

- Each sector is monopolistically competitive with *nominal rigidities κ varying across sectors*; Cobb-Douglas production function with weights $\boldsymbol{\alpha}$ on labor and Ω on intermediate inputs

$$\boldsymbol{\pi_t} = K(\boldsymbol{\alpha} y_t - (I - \Omega)\boldsymbol{s_t} + \boldsymbol{\epsilon}\tau_t) + \beta \boldsymbol{E}_t \boldsymbol{\pi_{t+1}}$$

  where K is a diagonal matrix with PC slopes κ_i on the diagonal, relative prices $\boldsymbol{s_t}$ follow $\boldsymbol{s_t} = \boldsymbol{s_{t-1}} + \boldsymbol{\pi_t} - \mathbf{1}\gamma'\boldsymbol{\pi_t}$, and γ are expenditure shares ($\gamma'\mathbf{1} = 1$, $\alpha + \Omega\mathbf{1} = \mathbf{1}$)

- Green transition = **tax** τ_t on "dirty sectors" to reduce dirty output (and therefore emissions), where $\boldsymbol{\epsilon}$ is the vector capturing the extent to which sectors are taxed (eg, proportional to emissions). Tax revenues are remitted lump sum to households.

Flexible prices equilibrium

- Potential output *decreases*

$$y_t^* = -\gamma'(I - \Omega)^{-1}\epsilon\tau_t$$

where $(\mathbf{I} - \mathbf{\Omega})^{-\mathbf{1}}\epsilon$ captures *both the direct and indirect* (via Ω) effect of taxation on marginal costs

- and relative price of the sectors (directly or indirectly) affected by the tax *in*creases:

$$\boldsymbol{s}_t^* = \underbrace{(I - \Omega)^{-1}\epsilon\tau_t}_{\uparrow} + \underbrace{\mathbf{1}y_t^*}_{\downarrow}$$

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$$\boldsymbol{s}_t^* = \underbrace{(I - \Omega)^{-1}\epsilon\tau_t}_{\uparrow} + \underbrace{\mathbf{1}y_t^*}_{\downarrow}$$

- The PC system can be expressed as: $\boldsymbol{\pi_t} = K(\boldsymbol{\alpha}(y_t - y_t^*) - (I - \Omega)(\boldsymbol{s_t} - \boldsymbol{s_t^*})) + \beta \boldsymbol{E}_t \boldsymbol{\pi_{t+1}}$

Some analytical results

- Assume that the carbon tax grows linearly forever ($\sim$ policy along the transition):

$$\tau_t = \tau_{t-1} + g$$

- **Proposition**: If policy closes the output gap ($y_t = y_t^*$), in response to a constantly growing carbon tax, aggregate inflation converges to:

$$\pi^{cpi} = \boldsymbol{\gamma}'\boldsymbol{\pi} = \left[\gamma' - \frac{\boldsymbol{\lambda}' K^{-1}}{\boldsymbol{\lambda}' K^{-1}\mathbf{1}}\right](1 - \Omega)^{-1}\boldsymbol{\epsilon} g$$

  where $\boldsymbol{\lambda}' = \gamma'(I - \Omega)^{-1}$ are the Domar weights, and $\boldsymbol{\lambda}' K^{-1}$ are the "divine coincidence" weights (Rubbo 2023)

No IO, same price stickiness

$$K = \kappa I,\ \Omega = \mathbf{0}_{n\times n}$$

- **Under** $y_t = y_t^*$ **aggregate inflation is zero**!

$$\pi^{cpi} = 0$$

No IO, same price stickiness

$$K = \kappa I,\ \Omega = \mathbf{0}_{n\times n}$$

- **Under** $y_t = y_t^*$ **aggregate inflation is zero**!

$$\pi^{cpi} = 0$$

- Intuition from a two-sector model (dirty and other). The Phillips curves are:

$$\pi_t^d = \kappa^d(y_t - y_t^* - \underbrace{(s_t^d - s_t^{d*})}_{<0}) + \beta \boldsymbol{E}_t \pi_{t+1}^d \quad \uparrow$$

$$\pi_t^o = \kappa^o(y_t - y_t^* - \underbrace{(s_t^o - s_t^{o*})}_{>0}) + \beta \boldsymbol{E}_t \pi_{t+1}^o \quad \downarrow$$

- If $\kappa^d = \kappa^o$

$$\pi_t^{cpi} = \gamma_o \pi_t^o + \gamma_d \pi_t^d = 0$$

  since $\boldsymbol{\gamma}' \boldsymbol{s}_t = \boldsymbol{\gamma}' \boldsymbol{s}_t^* = 0$ and $y_t = y_t^*$

  All the work is done by relative prices!

IO, same price stickiness

$$K = \kappa I,\ \Omega \neq \mathbf{0}_{n\times n}$$

- **Under $y_t = y_t^*$ aggregate PPI inflation is zero, but CPI inflation is likely negative**!

$$\pi^{ppi} = \boldsymbol{\lambda}'\boldsymbol{\pi} = 0,\ \pi^{cpi} = -\frac{\boldsymbol{\lambda}'\Delta \boldsymbol{s}}{\boldsymbol{\lambda}'\mathbf{1}} = \left(\gamma' - \frac{1}{\boldsymbol{\lambda}'\mathbf{1}}\boldsymbol{\lambda}'\right)\underbrace{(I-\Omega)^{-1}\boldsymbol{\epsilon}}_{\text{direct + indirect}}\, g < 0$$

if sectors with higher (both direct and indirect) taxes have a higher consumption weight than their Domar weight —that is, *if more heavily taxed sectors are upstream*

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  if sectors with higher (both direct and indirect) taxes have a higher consumption weight than their Domar weight —that is, *if more heavily taxed sectors are upstream*

- In a two-sector model where dirty is an intermediate input for other (but not viceversa) we have:

$$\pi_t^d = \kappa(y_t - y_t^* - (s_t^d - s_t^{d*})) + \beta \boldsymbol{E}_t \pi_{t+1}^d \quad \uparrow$$

$$\pi_t^o = \kappa((1-\omega_{od})(y_t - y_t^*) - (s_t^o - s_t^{o*}) + \underbrace{\omega_{od}(s_t^d - s_t^{d*})}_{<0}) + \beta \boldsymbol{E}_t \pi_{t+1}^o \quad \downarrow\downarrow$$

- If for all t $y_t = y_t^*$, while $s_t^d < s_t^{d*}$

$$\pi_t^{cpi} = \gamma_o \pi_t^o + \gamma_d \pi_t^d = \gamma_o \kappa \omega_{od} \sum_{k=0}^{\infty} \beta^k \underbrace{(s_{t+k}^d - s_{t+k}^{d*})}_{<0}$$

No IO, different price stickiness

$\Omega = \mathbf{0}_{n\times n}$ but different κ's

- Aggregate inflation is given by

$$\pi^{cpi} = \left[\gamma' - \frac{\gamma' K^{-1}}{\gamma' K^{-1}\mathbf{1}}\right]\boldsymbol{\epsilon} g = \frac{1}{\sum_j \gamma_j \kappa_j^{-1}} \sum_i \gamma_i \epsilon_i \left(\sum_j \gamma_j \kappa_j^{-1} - \kappa_i^{-1}\right) g$$

- Inflation is positive if *sectors with higher taxes (ϵ_i) have more flexible prices (lower κ_i^{-1}) than the average sector*

No IO, different price stickiness

$$\Omega = \mathbf{0}_{n\times n} \text{ but different } \kappa\text{'s}$$

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- Inflation is positive if *sectors with higher taxes* (ϵ_i) *have more flexible prices (lower* κ_i^{-1}) *than the average sector*
- In a two-sector model with *fully flexible* dirty and *sticky* other:

$$s_t^d - s_t^{d*} = y_t - y_t^*$$
$$\pi_t^o = \kappa^o(y_t - y_t^* - (s_t^o - s_t^{o*})) + \beta \boldsymbol{E}_t \pi_{t+1}^o$$
$$\pi_t^{cpi} = \pi_t^o - \Delta s_t^o$$

- If $y_t = y_t^*$ then $\pi_t^{cpi} = -\Delta s_t^o > 0$. Having $\pi_t^{cpi} = 0$ requires a negative output gap $y_t < y_t^*$
- No tradeoff between stabilizing "core" ($\pi_t^o = 0$) and closing output gap (Aoki 2011, Olovsson and Vestin 2023)

General case

- CPI inflation is positive if sectors with higher (both direct and indirect) taxes have a higher consumption weight than their *divine coincidence* weight (low for flexible sectors, higher for upstream sectors)

$$\pi^{cpi} = \left[\gamma' - \frac{\boldsymbol{\lambda}' K^{-1}}{\boldsymbol{\lambda}' K^{-1}\mathbf{1}}\right] \underbrace{(I - \Omega)^{-1}\boldsymbol{\epsilon}}_{\text{direct + indirect}} \, g$$

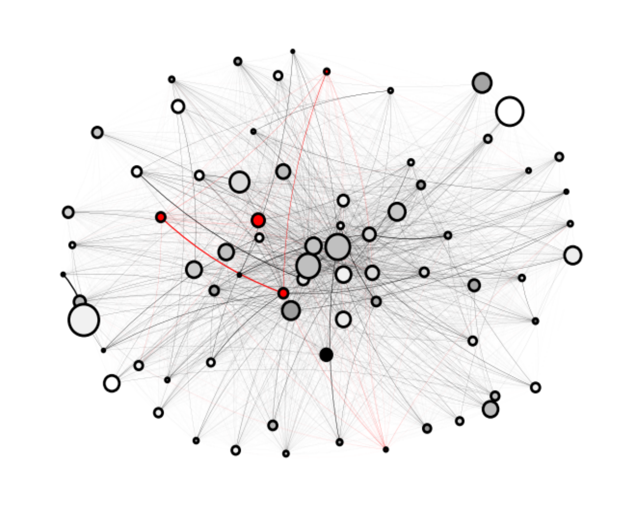
back

- Bottom line: **the interaction between relative stickiness** $(\gamma' - \frac{\boldsymbol{\lambda}' K^{-1}}{\boldsymbol{\lambda}' K^{-1}\mathbf{1}})$ **and the propagation via the IO network** $((I - \Omega)^{-1}\epsilon \neq \Omega\epsilon)$ **is key for the inflationary impact of the carbon tax**
- All of the above is just an application of the lessons from the network literature studying inflation, especially Rubbo, 2023, 2026 and Afrouzi and Bhattarai, 2023

The quantitative I/O model

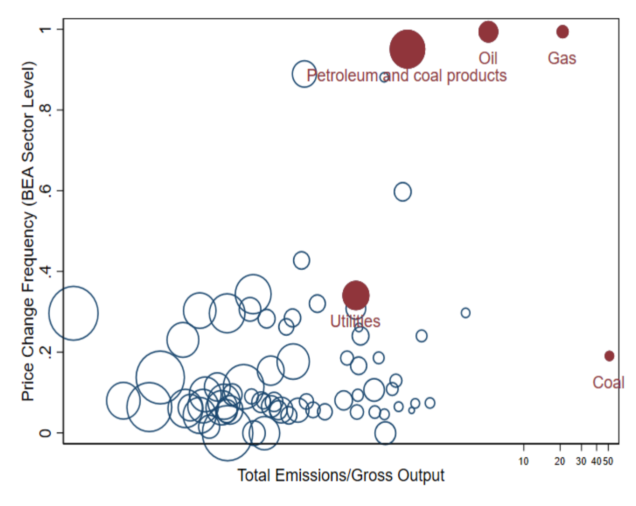
Features of the U.S. I/O network

1. Energy is **central**



Features of the U.S. I/O network

❷ Prices in sectors that are (directly or indirectly) affected by the tax are more flexible relative to prices in the rest of the economy



The I/O model

- Nested CES structure:
  - Firms in sector i produce using CES aggregate of labor and intermediate inputs (w elasticity η)

$$X_t^i = A_t^i \left[\alpha_i^{\frac{1}{\eta}} (L_t^i)^{\frac{\eta-1}{\eta}} + (1-\alpha_i)^{\frac{1}{\eta}} (I_t^i)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

  - Intermediate inputs are aggregate (w elasticity ν) of energy and non-energy inputs, each of which is aggregate of sectoral output (w elasticity ξ):

$$I_t^i = \left[\varsigma_i^{\frac{1}{\nu}} (E_t^i)^{\frac{\nu-1}{\nu}} + (1-\varsigma_i)^{\frac{1}{\nu}} (N_t^i)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}$$

and

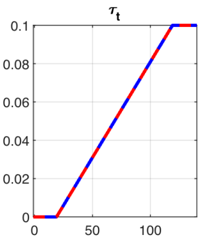
$$E_t^i = \left[\sum_j (\omega_{ij}^E)^{\frac{1}{\xi}} (X_t^{ij})^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \quad N_t^i = \left[\sum_j (\omega_{ij}^N)^{\frac{1}{\xi}} (X_t^{ij})^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}$$

  - Consumption is CES aggregate (ζ)

$$C_t = \left[\sum_i (\gamma_i)^{\frac{1}{\zeta}} (C_t^i)^{\frac{\zeta-1}{\zeta}} \right]^{\frac{\zeta}{\zeta-1}}$$

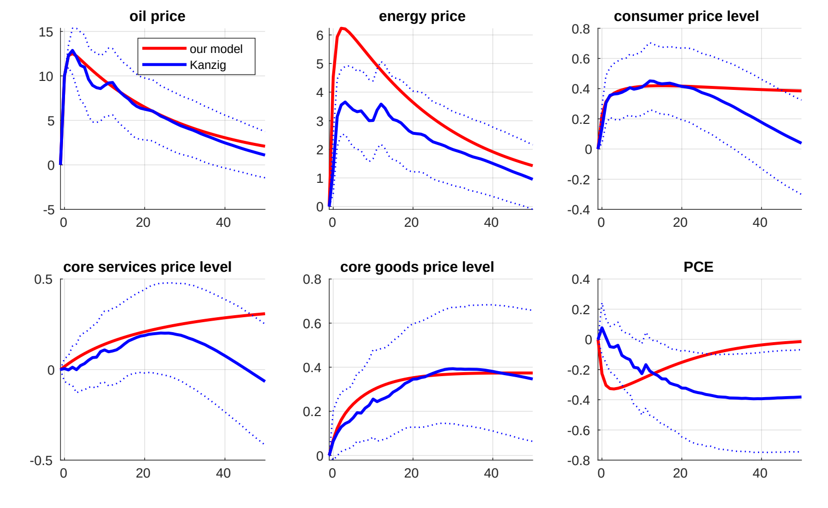
Calibration

- Consumption shares and sectoral input-output linkages: BEA 2012 input-output tables
- Monthly frequencies of price adjustment by sector $1 - \theta_i$: Cotton and Garga (2022)
- Carbon tax levied upstream on oil & gas extraction and coal mining based on *raw* CO_2 *emissions* (from EIA energy usage data and EPA emissions intensity data)
- Key elasticities taken from the literature: $\nu = 0.2$ (Bachmann et al. 2022); $\xi = 0.1$ (Atalay 2017); $\eta = 0.6$ (Oberfield and Raval 2021); $\zeta = 2$ (Hobijn and Nechio 2019)
- Tax gradually increases from 0 to 100 \$ over 100 months ($\sim$ carbon pricing policy scenario in Barron et al., 2018), anticipated 20 months in advance



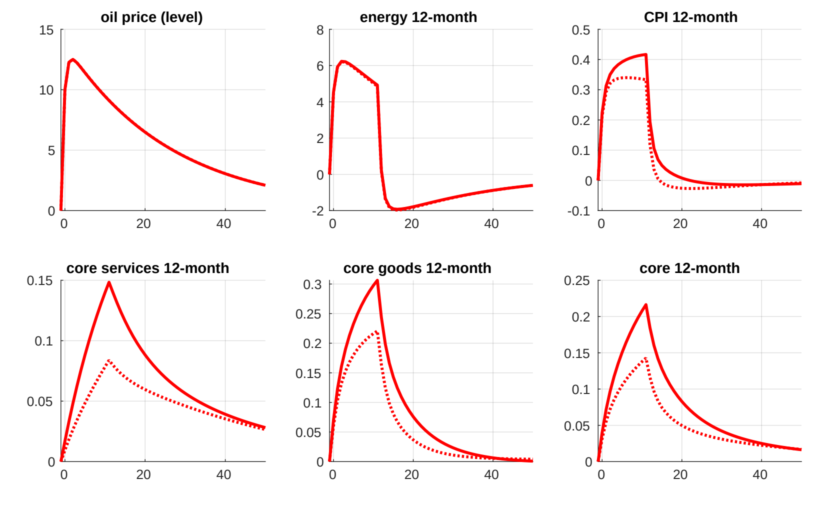
Validation: Model vs Känzig's energy price shock

- Compare the effect of WTI oil price shocks in the model to those estimated by Känzig (AER 2022)
- Markup process in the model calibrated to match oil price IRFs in Kanzig; propagation is driven by the model with no attempt toward "estimation" of the model parameters
- Model matches *levels* surprisingly well, at least up to 2 years



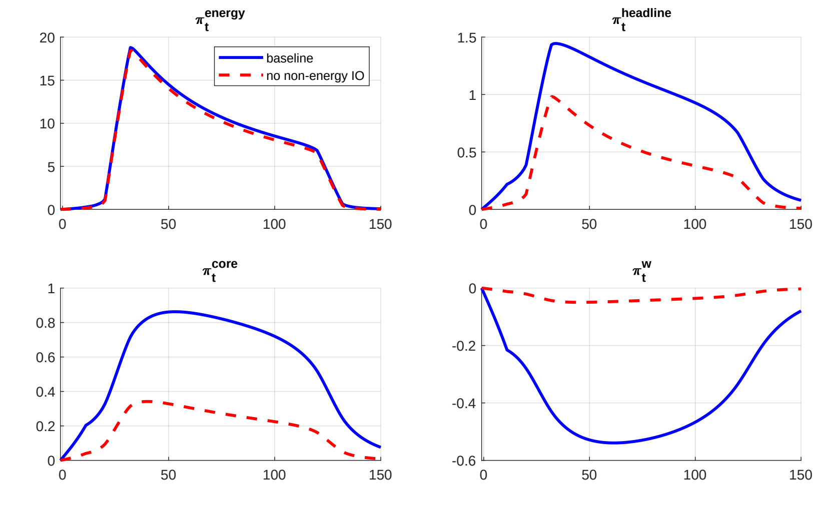
Propagation via the I/O network

- Solid red: same IRFs as above but in terms of 12-month inflation (except for oil)
- Dotted red: **counterfactual** without I/O network *except* for energy (400 sectors)
- For *core* (and services), **network is half of the story**



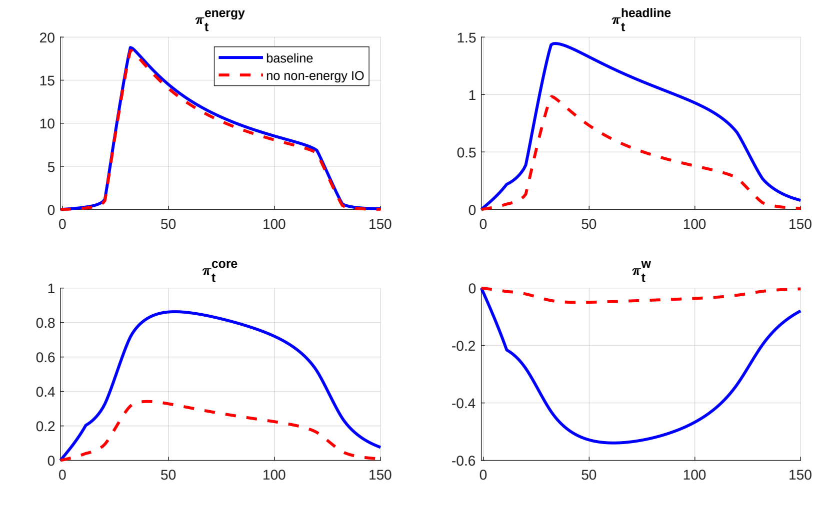
Non-linear dynamics under *output gap* targeting

- Focusing on the blue line, the tax has **substantial inflationary implications**
- 12 month *headline* CPI is *one percent or more above target* for more than *6 years*
- 12 month *core* CPI is *.5 percent or more above target* for about *10 years* (and .8 or more above target for about 3)



Propagation via the I/O network

- Dashed red: **counterfactual** without I/O network *except* for energy
- For *headline* **network** accounts for btw one third and half of the responses
- For *core* **network is two thirds of the impact**



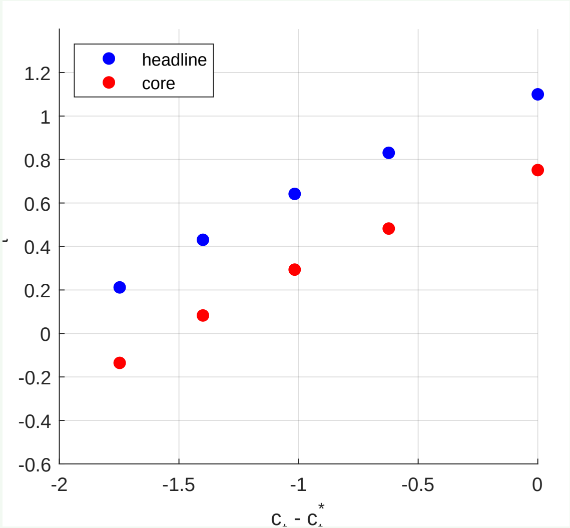
Tradeoffs in the quantitative I/O model

- Tradeoffs are unfavorable to the central bank
- controlling **headline** inflation (eg, $< .6$ on average for more than 8 years) takes a 1 percent average *"output" gap* over the same period
- controlling **core** inflation (eg, $< .5$) leads to a $>.5$ percent *contraction*

Robustness to elasticities

Emissions

100 months



Lessons from this paper

- Green transition generates a **trade-off between real activity and inflation**
- The interaction of **relative stickiness** and the **I/O network** is key

“A Network-Based Time Series Model for Inflation”

Goal

We propose a time-series model for U.S. inflation based on the input-output network, which we estimate using disaggregated sectoral inflation data (and other macro variables)

Why?

1. **Current time series models used to forecast/analyze inflation dynamics generally ignore the network structure of the US economy**
    - "Bottom-up" approaches forecast sectoral inflation rates and aggregate them up but treat them as independent
    - Models like Stock and Watson (2016)/NY Fed's MCT may use sectoral inflation data, but sectoral trends/shocks evolve independently from one another (save for the common trend/shock)
2. **Let's put this theory to the test** by seeing if it can produce 1) accurate forecasts of inflation; 2) "realistic" impulse responses

How?

- We can (and do) estimate the network DSGE model (Smets, Tielens, & Van Hove, 2019; Ruge-Murcia & Wolman, 2022)
- ... but DSGE model estimation implies taking the model literally; a more reduced form approach that incorporates some of the restrictions from network models may be desirable
- Existing network/spatial dynamic models (SARs) are arguably not fully adequate — restrictions these models impose are **not** consistent with theory
- The **DSGE-VAR** approach (Del Negro & Schorfheide, 2004; Del Negro, Schorfheide, Smets, & Wouters, 2007) —**using the Network DSGE to generate a prior for a VAR** —offers an alternative
  - Very preliminary results suggest that it may work well at forecasting US inflation

Existing reduced form approaches for network models: SARs

SARs

- SARs (spatial autoregressions/Durbin models)

$$\boldsymbol{\pi}_t = \eta\Omega\boldsymbol{\pi}_t + \rho_1\Omega\boldsymbol{\pi}_{t-1} + \rho_2\Omega\boldsymbol{\pi}_{t-2} + ... + \varepsilon_t$$

$\Rightarrow$ *restricted* VAR

$$\boldsymbol{\pi}_t = (I - \eta\Omega)^{-1}\rho\Omega\boldsymbol{\pi}_{t-1} + (I - \eta\Omega)^{-1}\rho_2\Omega\boldsymbol{\pi}_{t-2} + ... + \varepsilon_t$$

  - "Macro" applications (Ozdagli and Weber, di Giovanni & Hale 2022) mostly static

- Restrictions are 1) at odds with theory, 2) dogmatic

DSGEVARs

(Del Negro & Schorfheide, 2004)

How do DSGEVARs work?

1. Generate λT artificial observations from the DSGE model: $Y^*_{\lambda T \times 1}$ and $X^*_{\lambda T \times k}$.

2. Stack actual and artificial observations, and compute the likelihood:

$$\propto \quad \underbrace{|\Sigma|^{-T/2} \exp\{-\frac{T}{2} tr[\Sigma^{-1}(\frac{Y'Y}{T} - 2\Phi' \frac{X'Y}{T} + \Phi' \frac{X'X}{T} \Phi)]\}}_{likelihood}$$
$$\underbrace{|\Sigma|^{-\lambda T/2} \exp\{-\frac{\lambda T}{2} tr[\Sigma^{-1}(\frac{Y^{*\,\prime} Y^*}{\lambda T} - 2\Phi' \frac{X^{*\,\prime} Y^*}{\lambda T} + \Phi' \frac{X^{*\,\prime} X^*}{\lambda T} \Phi)]\}}_{prior}$$

.

3. The posterior is

$$\propto N(\bar{\Phi}, \Sigma \otimes (X'X + X^{*\prime}X^*)^{-1}) \;\; \mathcal{IW}\Big((1+\lambda)T - k, S\Big)$$

where:

$$\bar{\Phi} = (\frac{X'X}{T} + \lambda \frac{X^{*\prime}X^*}{\lambda T})^{-1} (\frac{X'Y}{T} + \lambda \frac{X^{*\prime}Y^*}{\lambda T})$$

Some results

A few more details on model and estimation

- PCs: $\pi_t^i = \kappa_i \left[\alpha_i (w_t - a_t) + \sum_j \omega_{ij} s_t^j - s_t^i \right] + \beta \pi_{t+1}^i + \mu_t^i + \mu_t^c, i = 1, ..., n$
  - Only 4 sectoral shocks (goods, services, energy, food)
- Wage PC: $\pi_t^w = \kappa_w (c_t - he^{-\gamma} c_{t-1} - w_t) + \beta \pi_{t+1}^w + \mu_t^w$
- Taylor: $R_t = \rho_R R_{t-1} + (1 - \rho_R) (\psi_1 (\pi_t - \pi_t^*) + \psi_2 c_t) + \epsilon_t^m$
- Euler: $c_t = -\frac{(1 - he^{-\gamma})}{\sigma_c (1 + he^{-\gamma})} (R_t - \boldsymbol{E}_t [\pi_{t+1}]) + \frac{he^{-\gamma}}{(1 + he^{-\gamma})} c_{t-1} + \frac{1}{(1 + he^{-\gamma})} \boldsymbol{E}_t [c_{t+1}] + b_t$

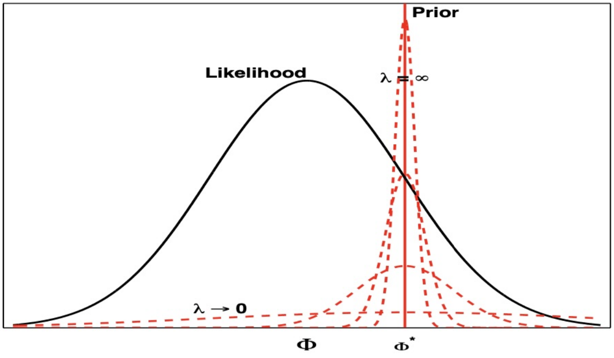
- Observables: core services, core goods, cpi energy, cpi inflation, real wage growth, nominal ffr, long-run inflation expectations; *we demean all the data*

- Sample: 1967Q1-2024Q2

How good is this network model? The choice of λ

- λ measures how tight the DSGE model-based prior should be
- λ is **data-driven**: for any λ compute the marginal likelihood of the DSGEVAR
- For the network model (sample 1967Q1-1990Q1) $\lambda = 2$ (twice as many dummy as actual observations) maximizes the marginal likelihood

VAR Likelihood and DSGE-based prior:



Log-marginal likelihood as a function of λ

$\lambda = .5$	$\lambda = 1$	$\lambda = 2$	$\lambda = 5$	$\lambda = \infty$
-43.3	-1.9	0.0	-16.2	-38.0

The Network DSGEVAR apparently forecasts CPI inflation pretty well

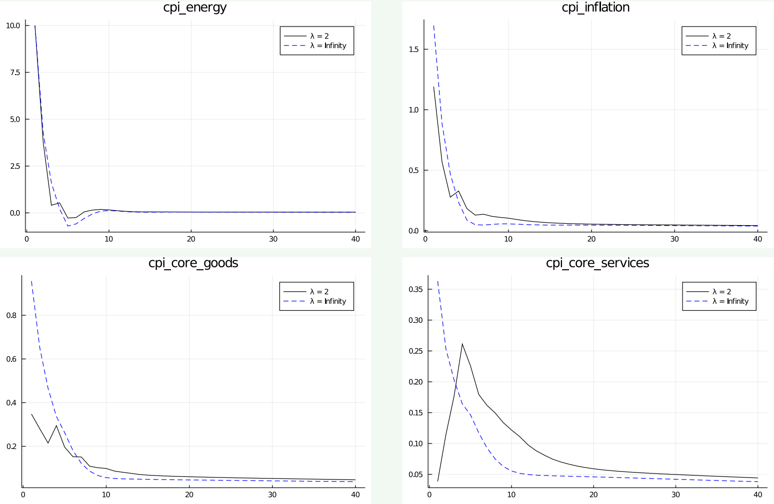
RSMSEs for CPI inflation forecasts: DSGEVAR($\lambda = 2$) vs AR2

Horizon	1990Q2-2024Q2			1990Q2-2019Q4		
(quarters ahead)	DSGEVAR	AR2	Improvement	DSGEVAR	AR2	Improvement
1	0.53	0.55	-0.02	0.48	0.53	-0.09
2	0.55	0.61	-0.11	0.53	0.60	-0.11
3	0.56	0.62	-0.09	0.52	0.59	-0.12
4	0.53	0.65	-0.18	0.51	0.62	-0.18
5	0.58	0.65	-0.11	0.49	0.61	-0.20
6	0.57	0.67	-0.14	0.50	0.63	-0.20
7	0.58	0.69	-0.16	0.52	0.66	-0.21
8	0.58	0.71	-0.18	0.52	0.68	-0.23

- AR2 is usually a pretty good forecasting model for inflation (see "DSGE model-based forecasting"); we plan to compare with Stock & Watson 2007 UCSV model and the MCT (SW 2016)

But some of its IRFs are at odds with those of the DSGE model

- Less impact, more persistence



Conclusions so far

- We propose using the **DSGE-VAR** approach **—using the Network New Keynesian DSGE to generate a prior for a VAR** —as a model for inflation analysis/forecasting
- Very preliminary results suggest that it may work well at forecasting US inflation and produce some empirical insights on important questions, such as the propagation of energy shocks

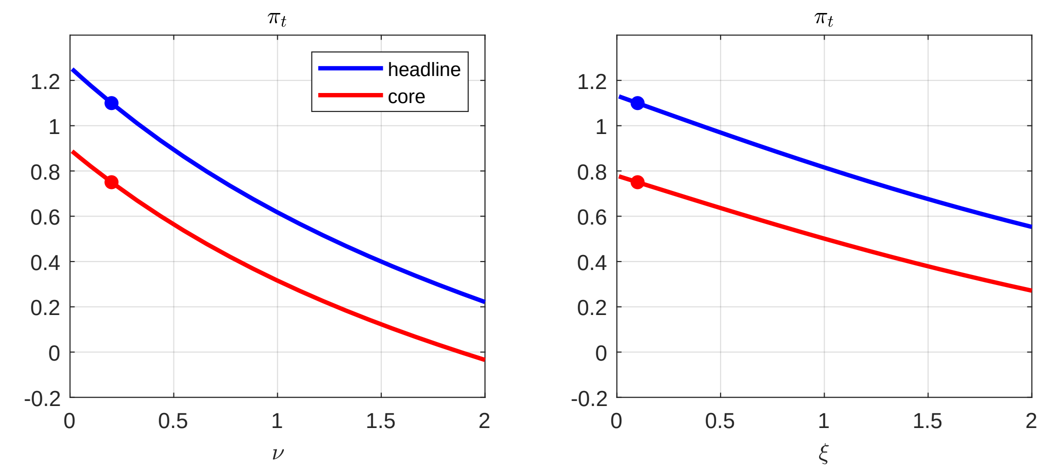
Bottom line: **Networks** (may) **matter for inflation**

Thank you!

The Fonz!

Robustness to the elasticities

Average inflation during 100 months of tax increase



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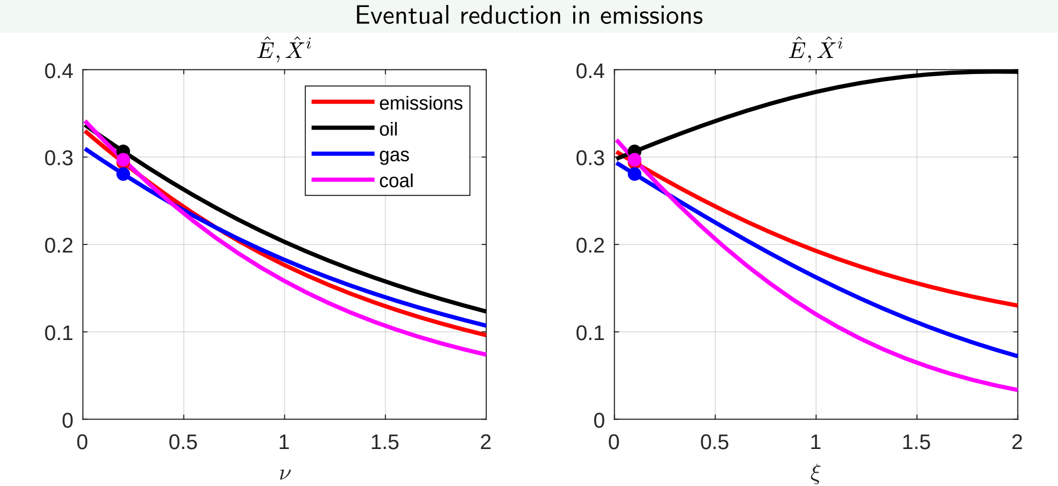
Emissions as a function of the elasticity of substitution



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