Is the Green Transition Inflationary?

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Question

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

Answer: conceptual

Two-sector model:

- The green transition does not force monetary policymakers to tolerate higher inflation, but can generate a **tradeoff** (inflation vs. output gap)
- Tradeoff depends on **relative stickiness** of 'dirty' vs 'other' prices
  - Green transition requires an increase in the *relative* price of dirty goods
  - If 'dirty' prices are relatively flexible and 'other' prices sticky (realistic case), this adjustment requires either inflation, or a recession to force 'other' prices down
- Tax on 'dirty' vs. subsidy on 'green' have opposite implications for inflation and the trade-off faced by the monetary policymaker

Answer: quantitative

$\sim$ *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 in turn inputs for the rest of the economy

- **Schnabel is right**: 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
  - Inflation can only stabilized at a cost of a sizable contraction in economic activity

Related literature

- **Empirical**
  - Metcalf and Stock (forthcoming) find little evidence of impact of transition policies on output
  - Känzig (2022) finds significant effects of carbon tax on inflation, while Konradt and Weder di Mauro (2021) find none
- **Theoretical**
  - *Positive*: 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.
  - **Olovsson and Vestin (2023)** use simple NK models with an energy sector to study the tradeoffs faced by monetary policymakers during the green transition, along the lines of our two-sector NK model

Analytical results from a two-sector model

Simple model

- Stylized two-sector New Keynesian model with '*d*irty' and '*o*ther' sectors
  - 'Dirty' represents goods and services with relatively high emissions
- Each sector is monopolistically competitive with nominal rigidities, which vary across sectors
  - Linear production in labor, no intermediate inputs (relax in paper & in quantitative model)
- Households' utility depends on $\ln C - bL$, where C is a Cobb-Douglas aggregate of d and o
- Green transition = **tax** on dirty sector production which gradually increases to a higher ss level, to reduce dirty output (and implicitly emissions, which are not directly modeled)

Phillips curves

- Model boils down to the sector i Phillips curves

$$\Pi_t^i(\Pi_t^i - 1) = \frac{\epsilon_t^i}{\Psi^i}\left(\frac{M_t^i}{P_t^i} - \frac{1}{\mu_t^i}\right) + \boldsymbol{E}_t\left\{\beta\Pi_{t+1}^i(\Pi_{t+1}^i - 1)\right\}, \ i = o, d$$

where marginal costs $\frac{M_t^i}{P_t^i} = \frac{W_t}{P_t^i A_t^i} + \frac{\mathcal{T}_t^i}{P_t^i} = \frac{bY_t}{A_t^i}\frac{P_t}{P_t^i} + \frac{\mathcal{T}_t^i}{P_t^i}$

$\Rightarrow$ Taxes act like cost-push/markup shock $\frac{1}{\mu_t^i}$: $\quad \frac{1}{\widetilde{\mu}_t^i} = \frac{1}{\mu_t^i} - \frac{\mathcal{T}_t^i}{P_t^i}, \ i = o, d$

Flexible prices equilibrium

- Relative price of the dirty sector *in*creases:

$$S_t^* = \frac{P_t^d}{P_t^o} = \frac{\widetilde{\mu}_t^d}{\mu_t^o}\frac{A_t^o}{A_t^d}$$

- Output in the dirty sector *de*creases (which is the point of the policy):

$$Y_t^{d*} = \frac{1}{b}\frac{A_t^d}{\widetilde{\mu}_t^d}$$

and so does the economy's potential output:

$$Y_t^* = \frac{1}{b}\left(\frac{A_t^o}{\mu_t^o}\right)^{\gamma}\left(\frac{A_t^d}{\widetilde{\mu}_t^d}\right)^{1-\gamma}$$

- **With flexible prices none of this matters for aggregate inflation**: the adjustment in relative prices can take place for *any* level of aggregate inflation (eg $P_t^d \uparrow$ and $P_t^o \downarrow$)

$\Rightarrow$ (relative) stickiness is key to understand inflationary implications of the green transition

Back to stickiness

- The (linearized) Phillips curves in the dirty and other sectors are

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

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

  where (these are just definitions):

$$\pi_t = \gamma \pi_t^o + (1-\gamma)\pi_t^d$$

$$s_t = s_{t-1} + \pi_t^d - \pi_t^o$$

- The name of the game is to understand what happens to π_t (and y_t) as $s_t \to s_t^*$ (which has gone $\uparrow$)
- ... and how these dynamics depend on monetary policy

Case 1: Dirty prices flexible ($\kappa^d = \infty$), other prices fixed ($\kappa^o = 0$),

- The only prices that move are the dirty ones, which must increase:

$$\pi_t = (1-\gamma)\pi_t^d = (1-\gamma)\Delta s_t$$

- Inflation is unavoidable

Case 2: Dirty prices flexible ($\kappa^d = \infty$), other prices sticky ($\kappa^o > 0$),

- $\pi_t^d > 0$ but now π_t^o can move

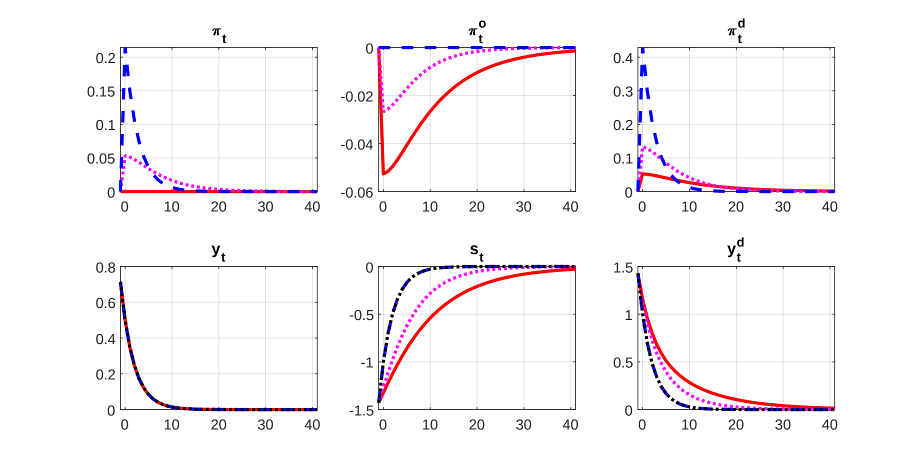
$$\pi_t = \pi_t^o + (1 - \gamma)\Delta s_t$$

and

$$\pi_t^o = \frac{\kappa^o}{\gamma}\left(y_t - y_t^*\right) + \beta \boldsymbol{E}_t \pi_{t+1}^o$$

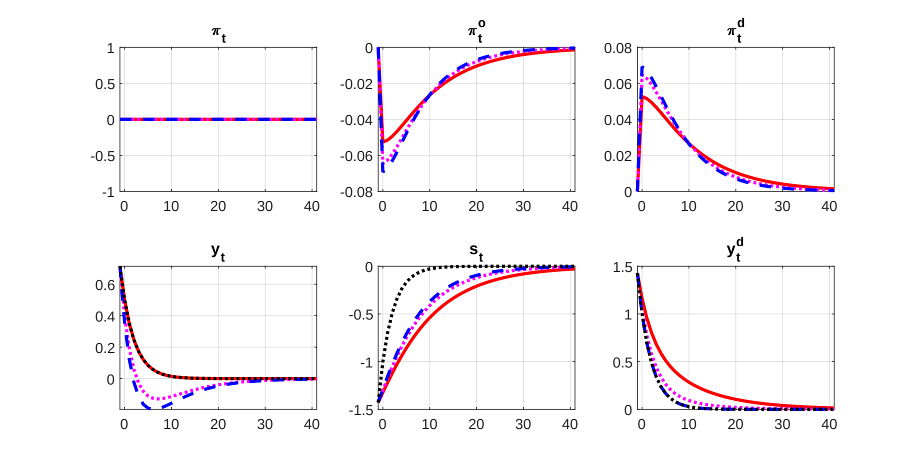
- Inflation is avoidable, but $\pi_t = 0$ requires a negative output gap $y_t < y_t^*$
- No tradeoff between stabilizing "core" ($\pi_t^o = 0$) and closing output gap (Rubbo 2023, Olovsson and Vestin 2023)

Dynamics under strict output gap targeting – simple model



Notes: Dotted black lines: **flexible price**; dashed blue: $\kappa^d = \infty$; red: $\kappa^o = \kappa^d$, magenta dotted: $\kappa^d = 5\kappa^o$

Dynamics under strict inflation targeting – simple model



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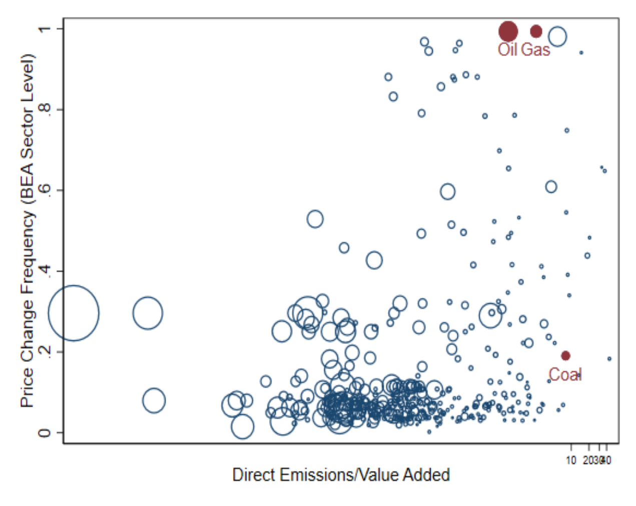
The quantitative I/O model

Why a quantitative I/O model?

1. Heterogeneity across sectors in the relationship between 'dirtiness' and stickiness
   - Dirty sectors tend to be stickier, but some dirty sectors are quite sticky
2. Network literature studying inflation (La'O & Tahbaz-Salehi, 2022; Rubbo, 2023; Afrouzi and Bhattarai, 2023): inflation-output tradeoff depends on interaction of heterogeneity in stickiness and I/O links
   - Sectors with large input-output adjusted price stickiness punch well above their (value-added) weight



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

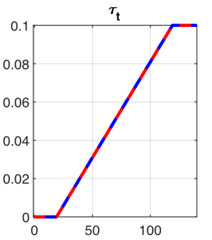
$$E_t^i = \left[\sum_j (\omega_{ij}^E)^{\frac{1}{\xi}} (X_t^{ij})^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \quad N_t^i = \left[\sum_j (\omega_{ij}^N)^{\frac{1}{\xi}} (X_t^{ij})^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}$$

  - Consumption is CES aggregate (ζ)

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

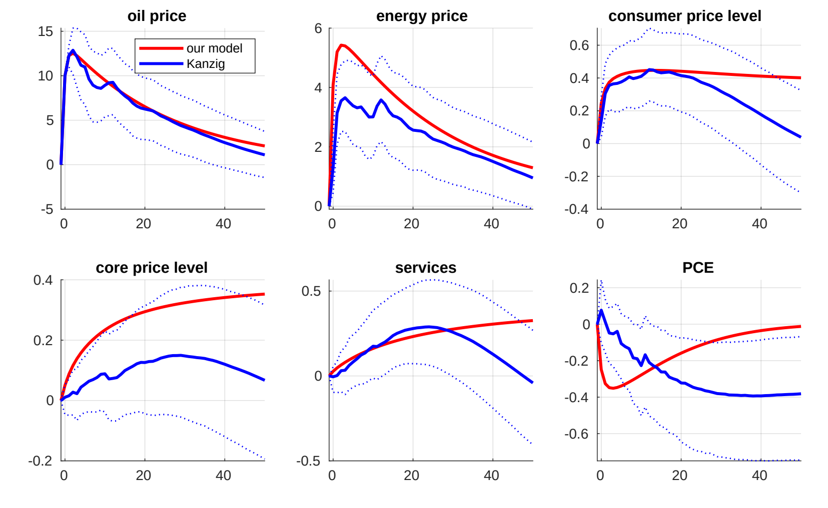
Calibration

- 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



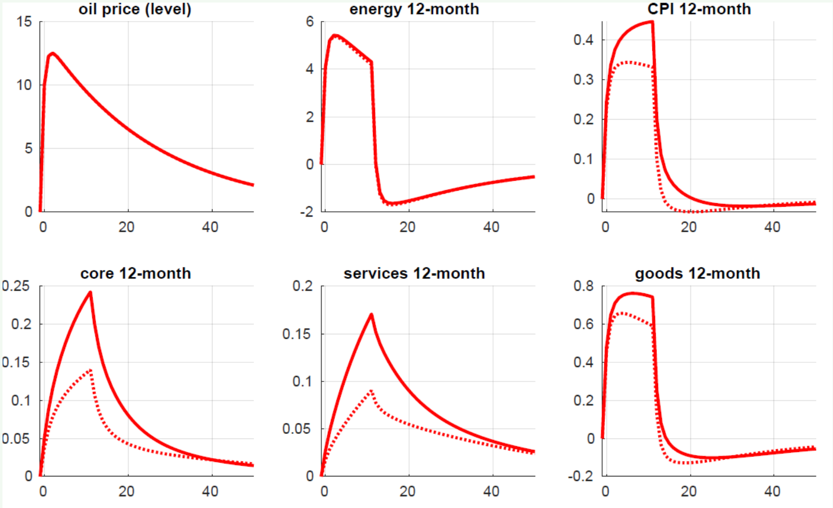
Validation (∼400 sector I/O model)

- Compare the effect of WTI oil price shocks in the model to those estimated by Kanzig (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



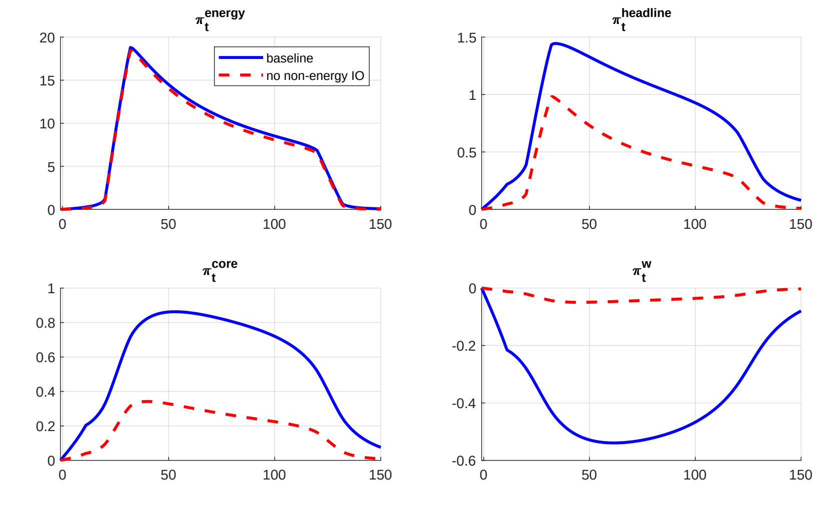
Propagation via the I/O network

- 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**



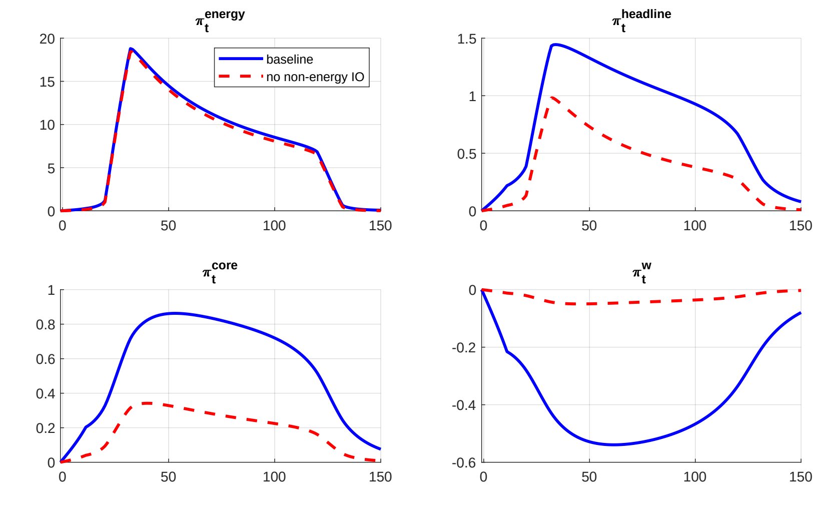
Non-linear dynamics under *output gap* targeting – ∼70 sectors I/O model

- 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

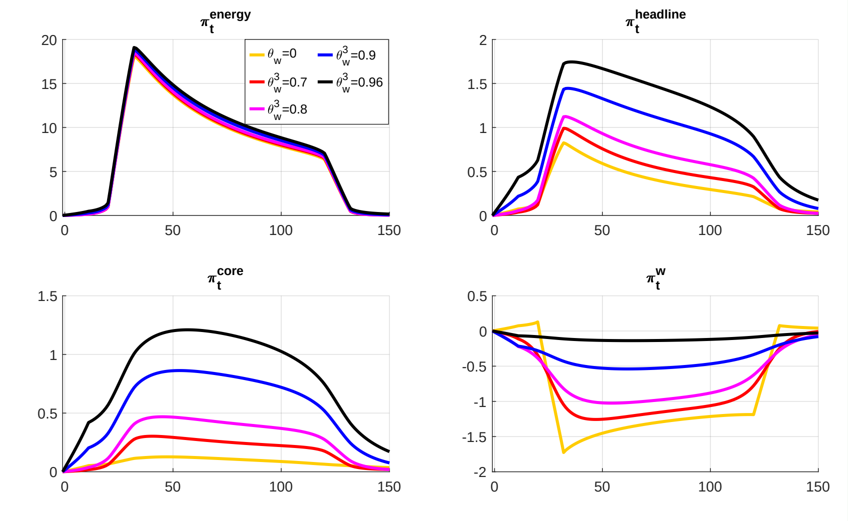
- Dashed red: **counterfactual** without I/O network *except* for energy
- For *headline* **network** accounts for btw one third and half of the responses
- For *core* **network is two thirds of the impact**



Importance of wage stickiness

- Without wage stickiness, the fall in wages compensates the increased energy costs $\rightarrow$ little happens to core inflation

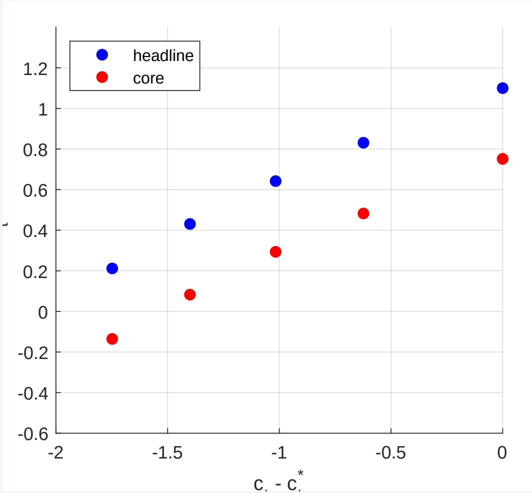
- With elevated (but still reasonable) wage stickiness, effect on headline and core inflation is large



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*

100 months



Summing Up

- Green transition generates a **trade-off between real activity and inflation**

- Following a gradual increase in carbon taxes from \$0 to \$100
    - *Core* inflation would be 50 to 100 bps higher than target for $\approx$ 10 years
    - Inflation can only stabilized at a cost of a sizable contraction in economic activity

- **Propagation** via the I/O network is key

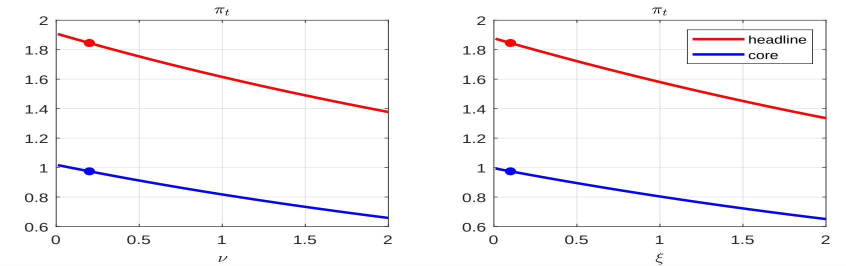
Thank you!

Robustness to the elasticities

- Inflation response not very sensitive to elasticities, for given tax
- Emissions are sensitive, but our choice of elasticities is quite low

back

12-month inflation



Eventual reduction in emissions