Virtual Seminar on Climate Economics

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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, 2002)

Answer: (1) conceptual

Two-sector model:

1. The green transition does not force monetary policymakers to tolerate higher inflation, but can generate a **tradeoff** (inflation vs. output gap)

2. Relative price **stickiness** in the rest of the economy ('other') compared with the 'dirty' sector is the key determinant of this trade-off
   - 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

3. Tax on 'dirty' vs. subsidy on 'green' have opposite implications for inflation and the trade-off faced by the monetary policymaker

Answer: (2) quantitative

$\sim$ 400-sector calibrated network model

1. The effect of 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
2. An increase in carbon taxes from \$0 to \$20 (2012 dollars) would generate a **sizable tradeoff**
   - Inflation (including core) can only stabilized via a deep recession, especially if wages are sticky
3. But the tradeoff is relatively *short-lived*
   - If monetary policy does not try to fight inflation (stabilizes the output gap) 12-month headline (core) inflation is 2% (1%) above target for one year but then wanes

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

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 $\dfrac{M_t^i}{P_t^i} = \dfrac{W_t}{P_t^i A_t^i} + \dfrac{\mathcal{T}_t^i}{P_t^i} = \dfrac{bY_t}{A_t^i}\dfrac{P_t}{P_t^i} + \dfrac{\mathcal{T}_t^i}{P_t^i}$

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

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

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

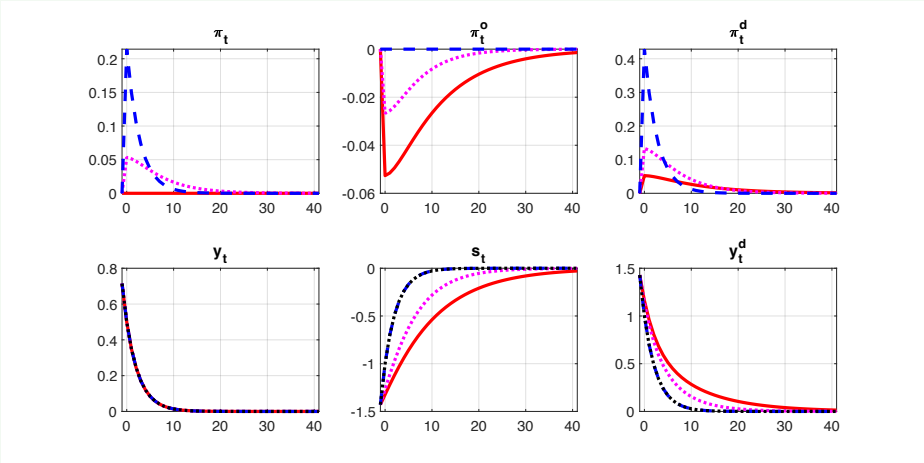
and

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

- Inflation is avoidable, but $\pi_t = 0$ requires a negative output gap $y_t < y_t^*$

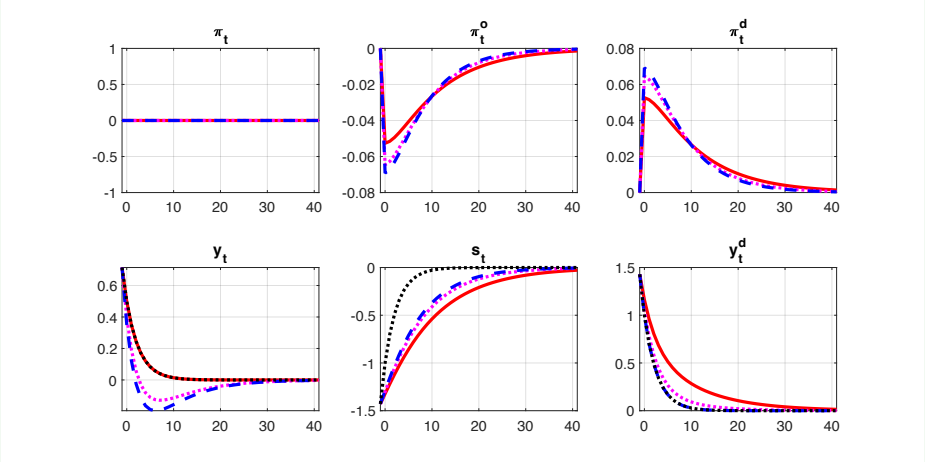
- No tradeoff between stabilizing "core" ($\pi_t^o = 0$) and closing output gap (Rubbo 2023, Olovsson and Vestin 2023)

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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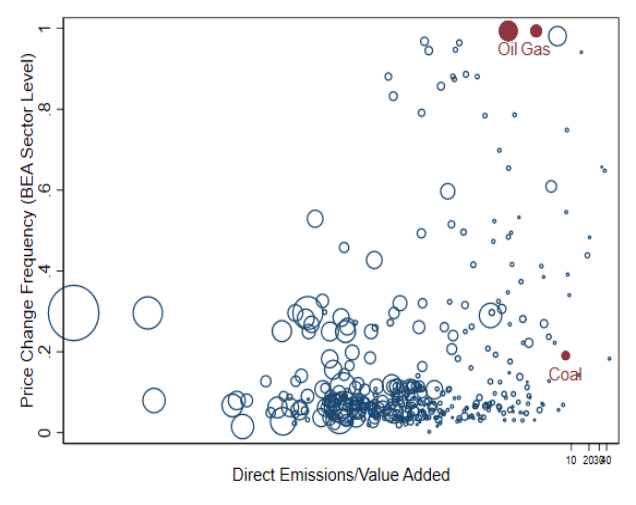
The quantitative I/O model

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 (LaO & 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)

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

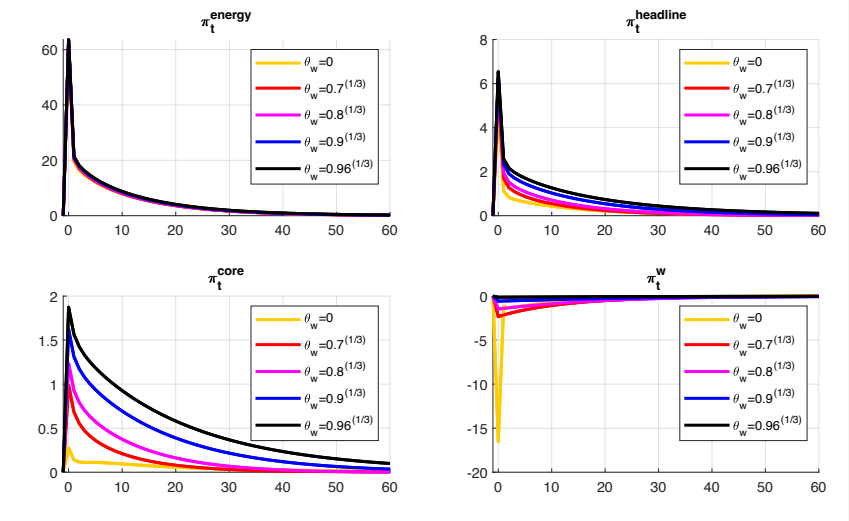
Calibration

- 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)
- Tax gradually increases to \$20/metric ton CO2 (2012 dollars): reduces emissions by 40%
- 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)

Dynamics under output gap targeting – I/O model

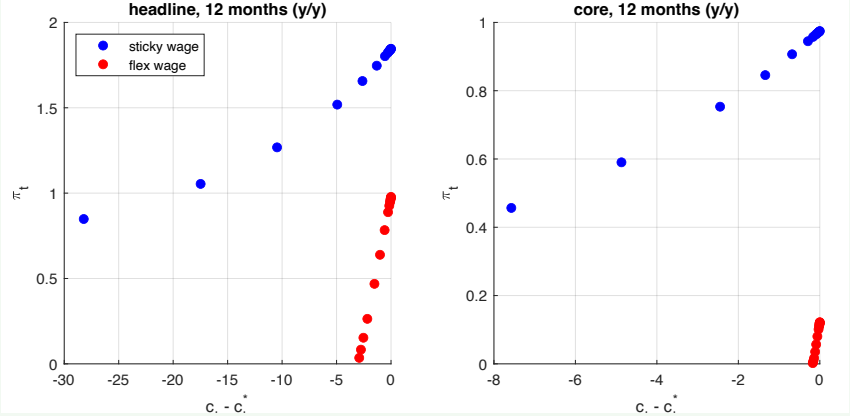
- Wage stickiness plays a key role: w/o it, the fall in wages compensates the increased energy costs $\rightarrow$ nothing happens to core inflation

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



Tradeoffs in the quantitative I/O model

- With wage stickiness tradeoffs are very unfavorable to the central bank
- controlling inflation (eg, headline < 1 or core $< .5$) leads to a <u>very large recession</u>
- but tradeoff is relatively "transitory" :-) If policymakers do nothing about inflation, it largely wanes after one year



Robustness to elasticities

Summing Up

- Green transition need not be inflationary
- ... but given empirically plausible assumptions about heterogeneous price stickiness across sectors (dirty sector prices are *less* sticky than rest of economy) it may generate a **trade-off between real activity and inflation**
- A calibrated network model suggests this tradeoff can be quantitatively **large**: containing the impact on headline or core inflation would lead to a **deep recession**.
- But the tradeoff is relatively **short-lived**: 12-month headline and core inflation are 2 and 1% above target for one year under strict output gap targeting, but then wane

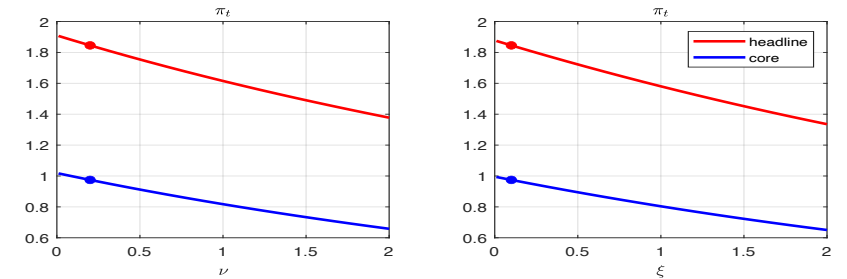
Thank you!

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