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)
- This paper provides a *conceptual* framework to address this question using a simple two-sector model
- and attempts to give some *quantitative* answers using a quantitative network model with almost 400 sectors calibrated to data on input-output linkages and sectoral heterogeneity in emissions and price stickiness

Answer

- Conceptually (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) for policymakers
   - In this sense Schnabel and others are correct in suggesting that climate policies may make policymakers' job harder

2. Price stickiness, and in particular the relative **stickiness** of prices in the 'dirty' ('green') sectors vs the rest of the economy, is the key determinant of the trade-off
   - The goal of climate policies is to achieve adjustment in *relative prices* of dirty vs other: if the rest of the economy is very sticky, this adjustment is either inflationary or needs a contraction in activity
   - With flexible prices there is no tradeoff

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

Answer

- Quantitatively (network model):

  1. An increase in carbon taxes from 0 to 20 (2012) dollars would generate a **sizable** tradeoff: containing the impact on headline or core inflation would lead to a deep recession

  2. But the tradeoff is relatively **short-lived**: 12-month headline and core inflation are 2 and 1 percent above target for one year under strict output gap targeting, but then inflation 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**
  - 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; 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. While these are also NK models, and hence incorporate some of the mechanisms outlined in this paper, they do not explicitly bring them to the fore
  - Olovsson and Vestin (2023) and Nakov and Thomas (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' in the 2-sector model is a stand-in for goods and services with relatively high greenhouse emissions
- Each sector is monopolistically competitive with nominal rigidities, which vary across sectors
  - Linear production in labor
- Households: Log utility in C and linear in L; consume a bundle of d and o
- Green transition amounts to **taxing** production (over time) in dirty sector with goal of reducing output and thus emissions
  - Symmetric case: **subsidies** to the green sector

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 $\frac{1}{\mu_t^i}$: $\qquad \frac{1}{\widetilde{\mu}_t^i} = \frac{1}{\mu_t^i} - \frac{\mathcal{T}_t^i}{P_t^i},\ i = o, d$

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 $P_t^o \downarrow$)

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

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

where

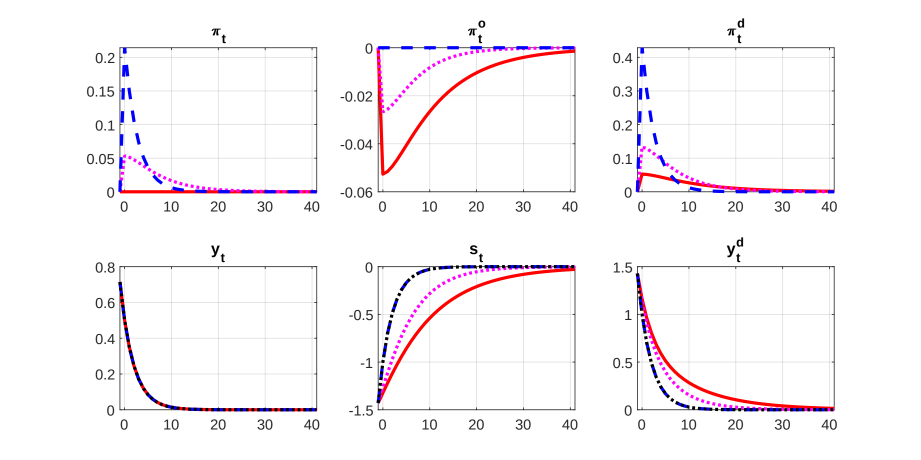
$$s_t = s_t^* + \frac{1}{\gamma}(y_t - y_t^*)$$

and

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

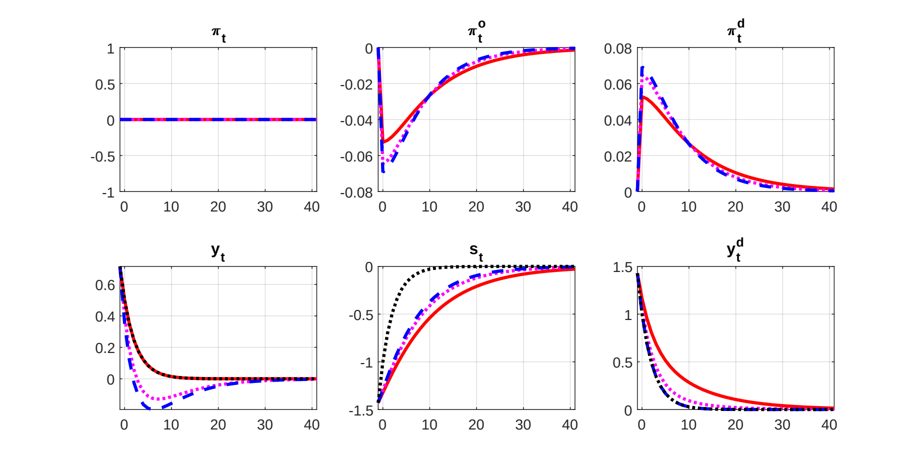
- Inflation is no longer unavoidable, but you need an open output gap $y_t < y_t^*$ to get $\pi_t = 0$ (or whatever the target)
- Note however that if you only care about "core" (π_t^o) then there is no tradeoff ($y_t = y_t^* \rightarrow \pi_t^o = 0$) – Olovsson and Vestin (2023)

Dynamics under strict output gap targeting



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



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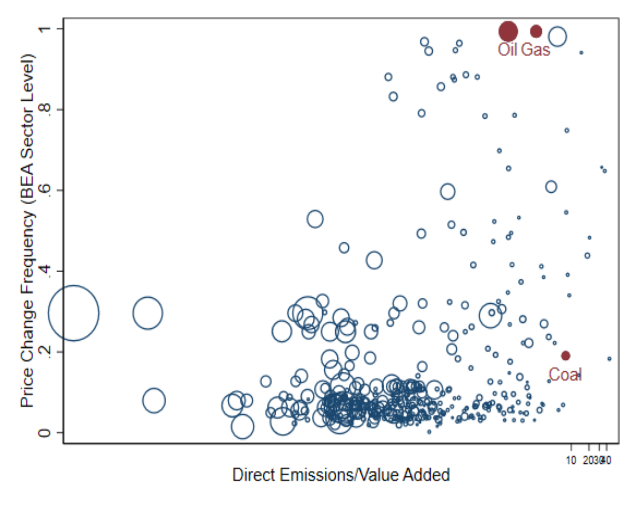
The quantitative I/O model

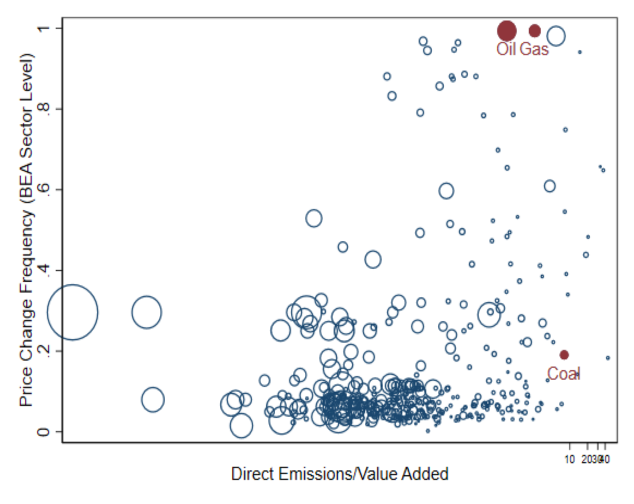
Why a quantitative I/O model?

1. Lots of heterogeneity across sectors in the relationship between 'dirtiness' and stickiness
   - Dirty sectors tend to be stickier, but some dirty sectors are quite sticky



Why a quantitative I/O model?

1. Lots of 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) has emphasized that the inflation-output tradeoff is driven by the 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

- Firms in sector i produce using nested CES:

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

where

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

and

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

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

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

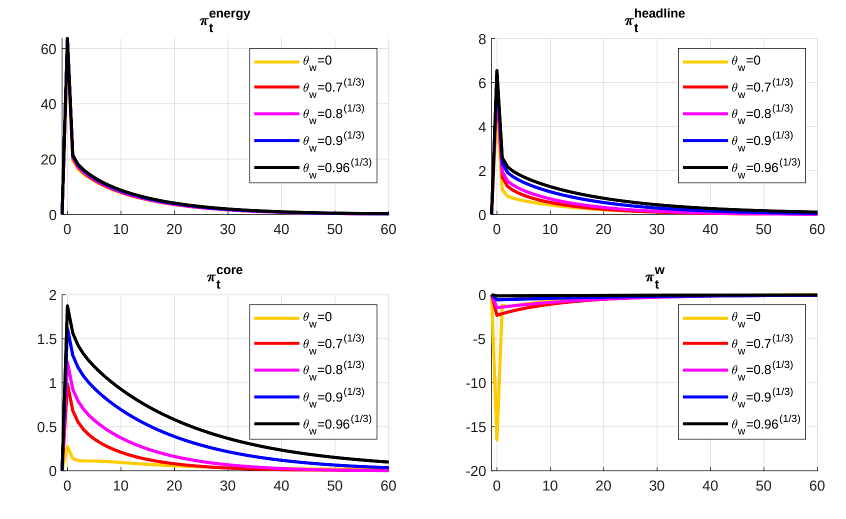
Calibration

- 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) (for six-digit NAICS sectors) based on Nakamura and Steinsson (2008)
- 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 (2012 dollars): reduces emissions by 40%, $\approx$ Biden admin's targets
- Key elasticities taken from the literature: energy vs non-energy inputs $\nu = 0.2$ (Bachmann et al. 2022); between intermediate inputs $\xi = 0.1$ (Atalay 2017); labor and intermediates $\eta = 0.6$ (Oberfield and Raval 2021); consumption goods $\eta = 2$ (Hobijn and Nechio 2019)

Dynamics under output gap targeting – I/O model

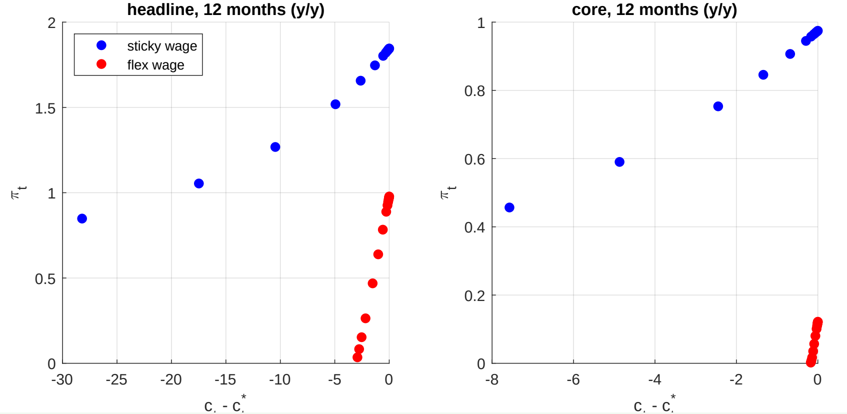
- Wage stickiness plays a key role: w/o it, the fall in wages compensates the increased energy costs → nothing happens to core inflation

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



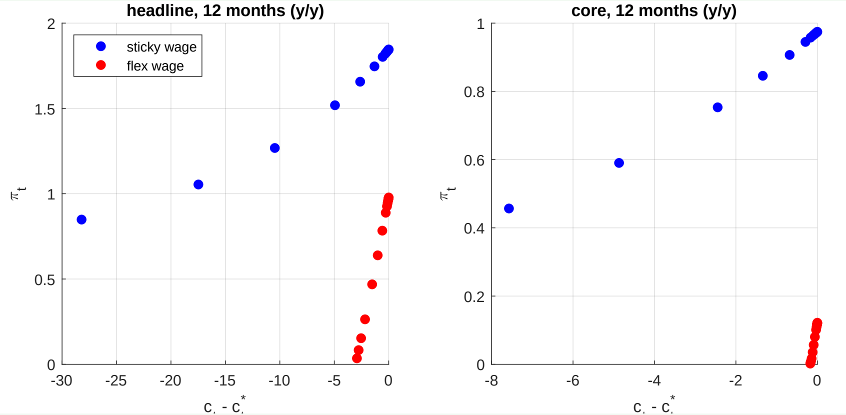
Tradeoffs in the quantitative I/O model

- With wage stickiness tradeoffs are very unfavorable to the central bank
- controlling inflation (eg, headline < 1 or core $< .5$) leads to a very large recession



Tradeoffs in the quantitative I/O model

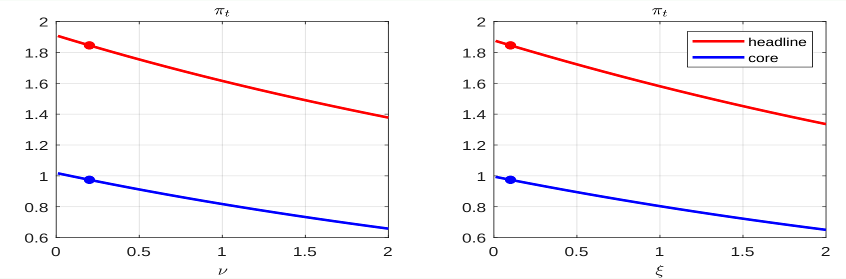
- With wage stickiness tradeoffs are very unfavorable to the central bank
- controlling inflation (eg, headline < 1 or core $< .5$) leads to a very large recession
- but tradeoff is relatively "transitory" :-) If policymakers do nothing about inflation, it largely wanes after one year



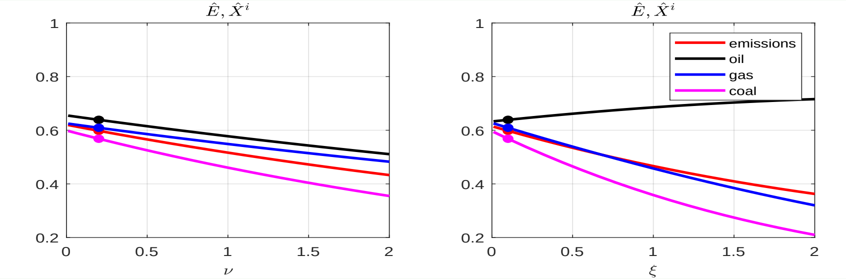
Robustness to the elasticities

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

12-month inflation



Eventual reduction in emissions



Summing Up

- Green transition does not have to be inflationary
- ... but given the empirically relevant relative price stickiness in the dirty sector and in the rest of the economy (dirty sector is *less* sticky) it may generate a **trade-off between real activity and inflation**
  - Intuition: Carbon tax increases relative price of dirty sector. In order to hit the inflation target, central bank needs to depress economic activity in order to nudge down inflation in the sticky sector
- Using a detailed quantitative network model calibrated to data on input-output linkages and sectoral heterogeneity in emissions and price stickiness we show that 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 percent above target for one year under strict output gap targeting, but then inflation wanes

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- But the tradeoff is relatively **short-lived**: 12-month headline and core inflation are 2 and 1 percent above target for one year under strict output gap targeting, but then inflation wanes
- **Opposite** story holds when **subsidizing green sector** $\Rightarrow$ may have deflation

Thank you!