Climate Transition: Subsidies v. Carbon Tax

Discussion of Fries and Aghion et al.

Neil R. Mehrotra

Federal Reserve Bank of Minneapolis

Peterson Institute - Macroeconomics of Climate Action
June 5, 2023

Summary

Fries paper:

- Question: What is the *macroeconomic* rationale for sequencing clean energy subsidies before a carbon tax?
- Insight: Clean energy becomes more substitutable for fossil energy as clean energy capital stock grows
- Implication: Microeconomic and macroeconomic factors favor subsidies

Aghion et al. paper:

- Question: Was shale boom beneficial for the clean energy transition?
- Insight: Directed technical change results in excessive innovation in fossil technologies
- Implication: Both subsidies and carbon tax needed to implement transition

Macroeconomic framework

Setup (BMW 2023)

Household/utilities investment problem:

$$\max \sum_{t=0}^{\infty} \beta^t u\left(C_t\right)$$

$$\text{subject to} \quad C_t + p_t^c I_t^c + p_t^f I_t^f = p_t^e E_t + \tau_c K_t^c - \tau_f K_t^f - T_t + W_t \bar{N}$$

$$E_t = G\left(K_t^c, K_t^f\right)$$

$$K_{t+1}^i = I_t^i + \left(1 - \delta_i\right) K_t^i \quad i \in \{c, f\}$$

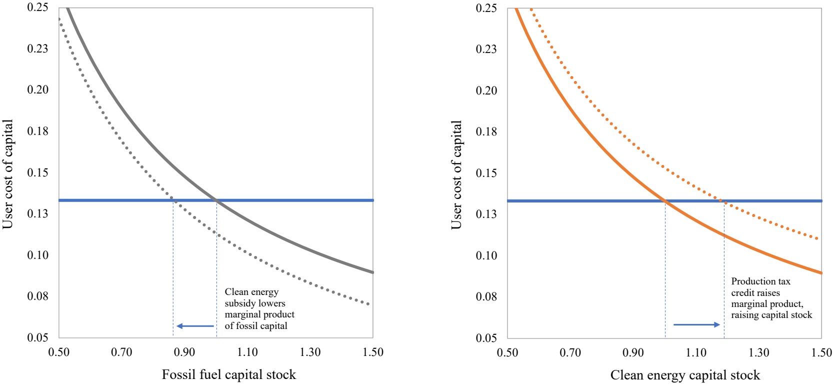
Output and electricity demand:

$$Y_t = F\left(E_t, \bar{N}\right)$$

$$p_t^e = F_e\left(E_t, \bar{N}\right)$$

Macroeconomic framework

Tax v. subsidy (BMW 2023)



- Clean energy subsidy is a supply-side policy: lower energy prices, higher output, productivity and wages

Optimal climate policy

Setup

$$\max \sum_{t=0}^{\infty} \beta^t \left[u\left(C_t\right) - d\left(S_t\right) \right]$$

$$\begin{aligned} C_t + p_t^c I_t^c + p_t^f I_t^f &= F\left(E_t, \bar{N}\right) \\ E_t &= G\left(K_t^c, K_t^f\right) \\ K_{t+1}^i &= I_t^i + \left(1 - \delta_i\right) K_t^i \quad i \in \{c, f\} \\ S_{t+1} &= S_t + \kappa K_t^f \end{aligned}$$

- Planner internalizes the environmental damage externalities from the fossil fuel capital
- Planner's resource constraint depends only on underlying technologies: $p_t^c,\ p_t^f,\ G\left(\cdot, \cdot\right)$

Optimal policy leaves clean energy margin undistorted

Utilities capital choice under subsidies/tax:

$$p_t^c = \frac{1}{1+r_t}\left[\left(p_{t+1}^e + \tau_{t+1}^c\right) G_c\left(K_{t+1}^c, K_{t+1}^f\right) + p_{t+1}^c\left(1-\delta_c\right)\right]$$
$$p_t^f = \frac{1}{1+r_t}\left[\left(p_{t+1}^e - \tau_{t+1}^f\right) G_f\left(K_{t+1}^c, K_{t+1}^f\right) + p_{t+1}^f\left(1-\delta_f\right)\right]$$

Planner's allocation:

$$p_t^c = \frac{1}{1+r_t}\left[p_{t+1}^e G_c\left(K_{t+1}^c, K_{t+1}^f\right) + p_{t+1}^c\left(1-\delta_c\right)\right]$$
$$p_t^f = \frac{1}{1+r_t}\left[p_{t+1}^e G_f\left(K_{t+1}^c, K_{t+1}^f\right) + p_{t+1}^f\left(1-\delta_f\right)\right] - \underbrace{\mu_{t+1}\kappa}_{\text{carbon tax}}$$

- The electricity production function $G\left(K_t^c, K_t^f\right)$ could be variable elasticity of substitution, but implies zero subsidy

Tax v. Subsidy under Innovation

setup

$$\max \sum_{t=0}^{\infty} \beta^t \left[u\left(C_t\right) - d\left(S_t\right)\right]$$

$$\begin{aligned}
C_t + p_t^c I_t^c + p_t^f I_t^f &= F\left(E_t, \bar{N}\right) \\
E_t &= G\left(K_t^c, K_t^f\right) \\
K_{t+1}^i &= I_t^i + \left(1 - \delta_i\right) K_t^i \quad i \in \{c, f\} \\
S_{t+1} &= S_t + \kappa K_t^f \\
p_{t+1}^i &= p_t^i \left(1 - \eta_i s_t^i\right) \quad i \in \{c, f\} \\
1 &= s_t^c + s_t^f
\end{aligned}$$

- Adaption of Acemoglu, Aghion, Bursztyn, and Hemous (2012)
- How does the planner allocate innovation effort between clean and fossil fuel energy?

Is the Private Allocation of Innovation Sub-optimal?

Optimal allocation of innovation:

$$\nu_t^i = \frac{1}{1+r_t}\left[I_{t+1}^i + \nu_{t+1}^i\left(1 - \eta_i s_{t+1}^i\right)\right] \quad i \in \{c, f\}$$

$$\nu_t^c \eta_c p_t^c = \nu_t^f \eta_f p_t^f$$

Discussion:

- The planner's allocation decision is undistorted relative to private sector allocation and optimal subsidy is zero
- Why does AABH (2012) and AABH (2023) find otherwise?
- Private sector innovation decisions is insufficiently forward-looking (static in AABH (2023))

Innovation and Price Mechanism

Role for research subsidies in AABH (2012) and successors:

- Innovation is generically undersupplied due to investment horizon and market structure
- Innovation in clean energy is disproportionately impacted due to low scale and low initial productivity

Inflation Reduction Act subsidies rely on price mechanism:

- IRA investment and production incentives induce upstream innovation only indirectly
- Justification for IRA incentives reliant on scale effects in manufacturing ("learning-by-doing") or financial frictions

Shale Boom and Clean Energy Innovation

- AABH (2023) model shale boom as productivity shock to natural gas energy production and extraction
- Fracking innovation has no applications for clean energy energy production in their model
- Fracking and, more generally, fossil fuel technologies may have important applications for clean energy
    - Enhanced geothermal requires fracturing hot rock formations and achieving greater drilling depths
    - Existing carbon capture used for enhanced oil recovery; techniques may be used for sequestration