The Macroeconomic Consequences of the Energy Transition: the Role of Capital Stocks and Rigidities in the FR-GREEN model

Fanny Henriet[1], Noëmie Lisack[2] & Harri Turunen[3]

[1]CNRS, Aix-Marseille School of Economics
[2]European Central Bank
[3]Banque de France

June 16, 2025

Preliminary results

This does not represent the views of the Banque de France or the European Central Bank.

Introduction

- The climate transition is not only a transition in energy production, but also in general production and consumption technologies
- Sizeable new investment into new clean capital and durables is required

- What is the macro impact of climate policy in a model for France that takes this into account?
- We evaluate the effect of a permanent carbon tax shock, a dirty investment tax and a clean investment subsidy

- In our model these shocks lead to a notable fall of output and income and under standard utility and headline targeting also of prices
- We alleviate forward-lookingness with wealth-in-utility which also implies that permanent income loss leads to permanent changes in the natural rate with implications for monetary policy

Main model ingredients and specificities

Transition in production and consumption technologies, not only energy production:

- Energy: Produced either with fossil fuels or using a capital good
  Used by households and firms
- Energy-specific capital and household durable stocks
- Investment irreversibility: dirty capital and durables can't be converted into clean ones

Household expectations:

- Standard version: perfect foresight $\Rightarrow$ Affects the inflation response (Ferrari & Nispi Landi, 2023)

$\Rightarrow$ Our alternative: wealth in utility (Michaillat & Saez, 2021) $\Rightarrow$ makes households less forward-looking

Within a relatively standard NK-DSGE

Some key findings

The climate policies have distinct real effects

- Carbon and dirty investment taxes cause output to fall
- Clean investment subsidies push output up

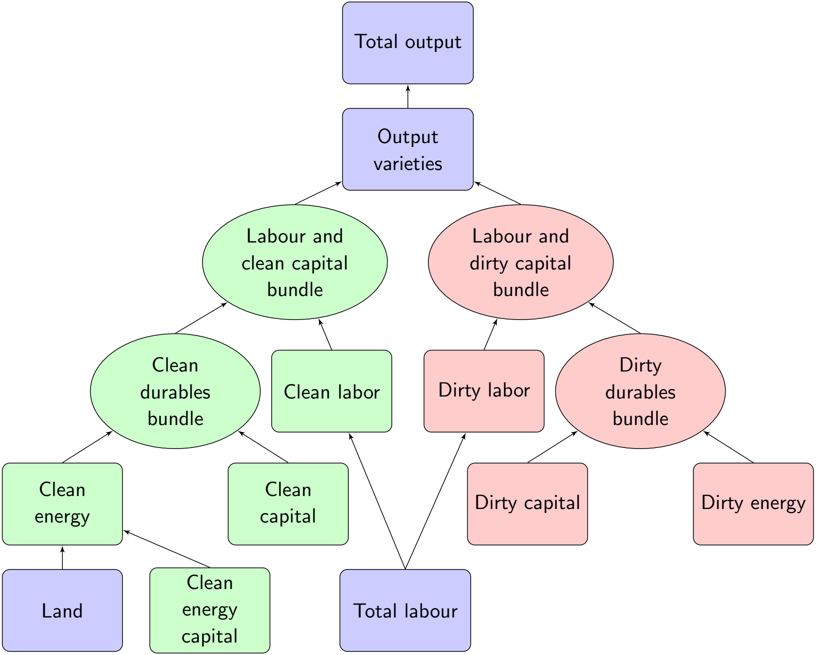
Strong forward-lookingness triggers deflation

- The policy shocks are a distorting cost-push shocks, causing a fall in income in the future and through the Euler equation in aggregate demand today
- Income effect dominates the cost effect under standard utility
- Through Calvo pricing, fall of demand leads to deflation

The inflation target plays a role

- Headline targeting is deflationary
- Core targeting is inflationary, leads to less output loss and speeds up the transition

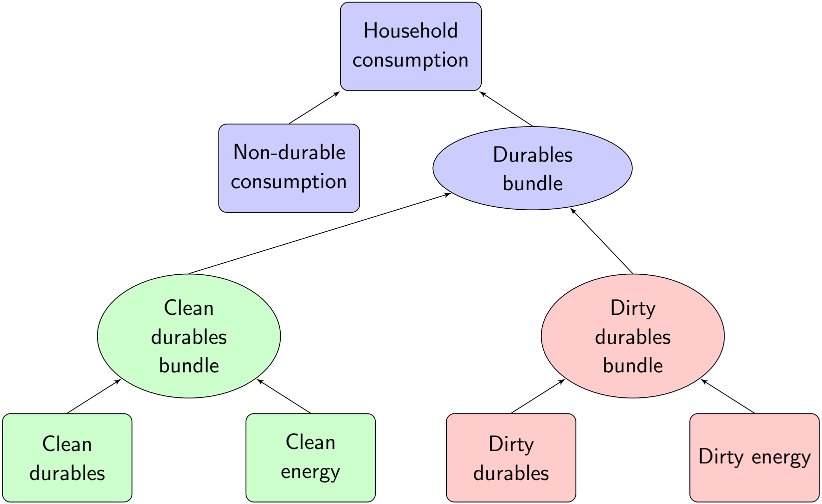
Production structure



Production

- Nested CES structure
- Final good producer: aggregates varieties of intermediate goods, perfect competition
- Intermediate good producers are monopolistically competitive (price setting à la Calvo) with indexation to past inflation
- All other bundle producers are perfectly competitive
- Investment adjustment costs
- Irreversibility of investment into capital
- Clean energy production using clean energy capital and "land" in fixed supply details

Consumption structure



Representative households

- Maximises discounted sum of CRRA utility by choosing consumption, investment, saving
- Consumption good: nested CES structure
- Consumes a bundle of durables and non-durables

- Labor supplied by households aggregated into clean and dirty sectoral labour, with imperfect substitution
- Wage for aggregate labor subject to Calvo stickiness with indexation to past wage inflation, sectoral wages flexible

- Investment adjustment costs
- Irreversibility of investment into durables

- Budget constraint: standard, receives (pays) a lump-sump transfer from (to) the government, owns the firms and receives their profits

Wealth in utility in the style of Michaillat & Saez (2021)

- Used by them to solve the forward guidance puzzle
- Additional term representing utility derived from all assets
- Household j gains utility from his relative real stock of assets via the function $u\left(\frac{S_{j,t}-\bar{s}_t}{P_t}\right)$, or $\gamma\frac{\left(\left(S_{j,t}-\bar{S}_t\right)/P_t\right)^{1-\eta_b}}{1-\eta_b}$ as in Zhao (2023)
- $u(.)$ appears additively in the periodic utility function
- Implied Euler equation (when $\eta_b = 0$)

$$\Lambda_t = \gamma + \beta E_t \Lambda_{t+1} \frac{R_t}{\pi_{t+1}} \quad \text{where} \quad \gamma = u'(0)$$

- Consumption-savings choice depends not only on interest rates but also on the marginal rate of substitution between wealth and consumption

⇒ Future consumption has less impact on today's consumption than in the standard model.

Implications of wealth in utility for the Taylor rule

Steady state Euler equation:

- Standard utility: interest rate depends only on β and inflation target
- With wealth in utility: steady state interest rate depends also on steady state marginal utility of consumption Λ

$$\Lambda = \gamma + \beta \Lambda \frac{R}{\pi}$$

Our policy experiment: **permanent** tax increase

- Permanent change in marginal utility of consumption
- Central bank has to adjust the intercept in the Taylor rule to bring inflation back to target
- Otherwise inflation gap never closes
- Similar to Campos et al (2024) and Nuno et al (2024)

Calibration

- Standard parameters: from the literature more
- Elasticities of substitution in the production structure and the household preferences: from the literature more
  High substitution possibility between clean and dirty bundles: EoS $= 10$
- Technical coefficients in the production function: targeting main macroeconomic ratios of the French economy (data from WIOD, PEFA, National accounts, Household expenditure surveys) more
- Wealth in utility parameters: following Michaillat and Saez (2021) and Rannenberg (2019,2021) more
  Lower discount factor with WIU
- Initial carbon tax level: using the effective carbon price of €90/TeCO_2 (OECD) more

Wealth in utility calibration

- From Michaillat & Saez (2021), $\eta_b = 0$:

  $$\Rightarrow u\left(\frac{S_{j,t} - \bar{S}_t}{P_t}\right) = \gamma \frac{S_{j,t} - \bar{S}_t}{P_t}$$

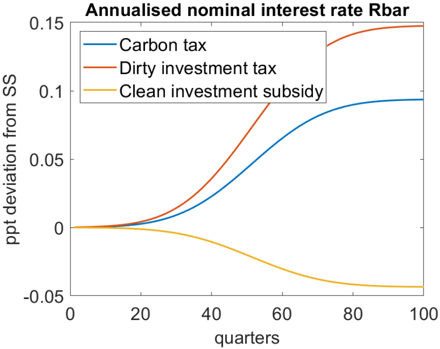
- From Rannenberg (2021, 2019): joint calibration of β and WIU parameter γ
  - Set initial steady state inflation $\bar{\pi}$ at the 2% target
  - Set initial steady state nominal interest rate $\bar{R}$ at 3.5%
  - Set the discounting wedge $\theta = \beta \frac{\bar{R}}{\bar{\pi}}$ at 1 without WIU, and 0.96 with WIU

    $\Rightarrow \beta = 0.9964$ without WIU, and 0.9565 with WIU
  - From the initial steady state Euler equation:

    $\Rightarrow \gamma = 0$ without WIU, and 0.0012 with WIU

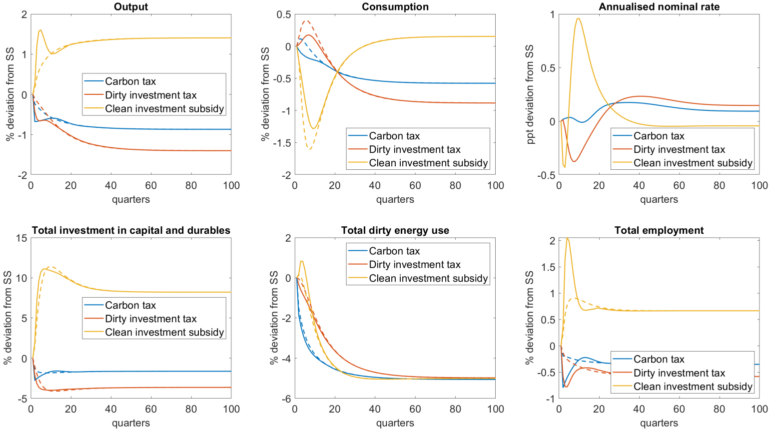
Policy experiments

- We consider three different gradual transition-inducing policies:
  - A carbon tax that increases carbon taxes by 24%
  - A tax on dirty investment that increases by 6.4%
  - A subsidy on clean investment that increases by 37%
- With wealth-in-utility, we assume gradual, S-shaped paths for the Taylor rule intercept

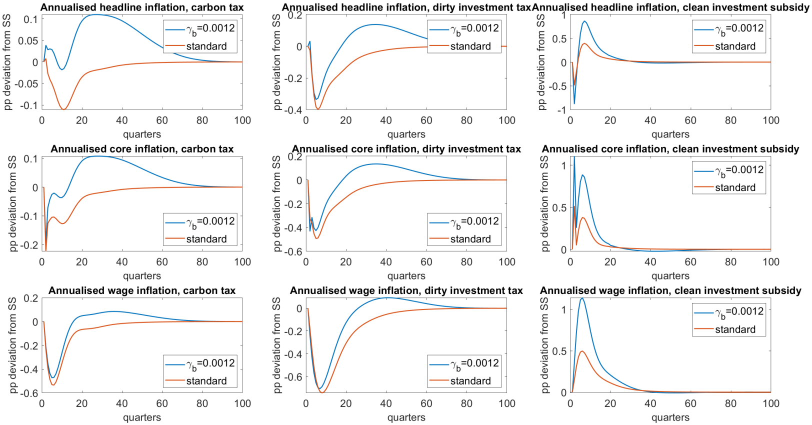


Real results with wealth in utility

Solid line – sticky prices, dashed line – flexible prices

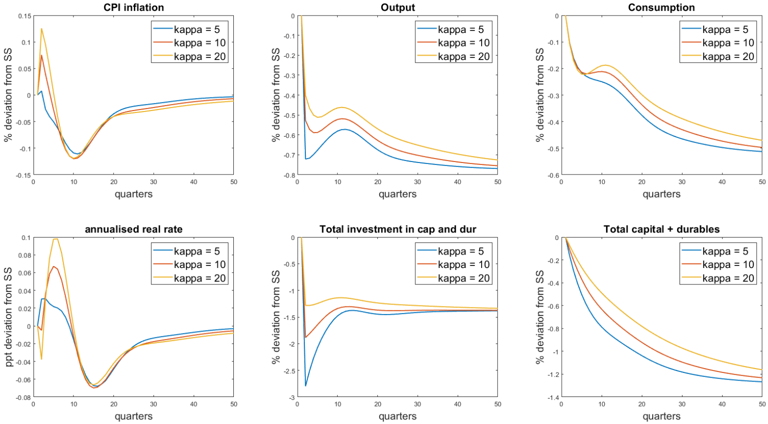


Impact on inflation with and without wealth in utility



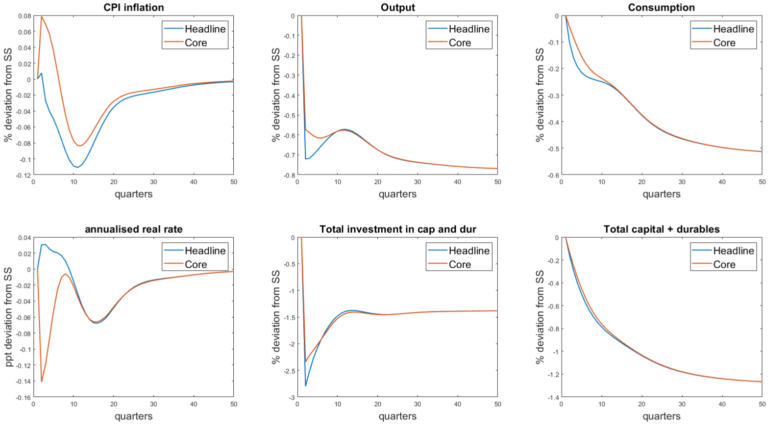
What drives the fall in aggregate demand?

The role of adjustment costs without wealth in utility



Carbon tax under different monetary policy targets

Headline vs. core targeting without wealth in utility



Conclusions and further work

The climate transition policies have distinct real effects

- Introduce a distortion in the production process
- Carbon and dirty investment taxes cause output to fall
- Clean investment subsidies push output up

If strong forward-looking behavior, a carbon tax:

- Implies an immediate fall in aggregate demand
- Can lead to deflation today

This depends on

- The inflation targeted by the Central Bank
- Under wealth-in-utility, how the CB adapts to changes in the natural rate

Reducing forward-lookingness with wealth-in-utility can lead to more intuitive outcomes for inflation

Appendix

Appendix: Clean energy production

- Clean energy is produced using clean energy capital and a "green factor" G combined in a CES function

$$E_{c,t} = \alpha_e \left(sK_{ce,t-1}^{\frac{\sigma_{ec}-1}{\sigma_{ec}}} + (1-s)G^{\frac{\sigma_{ec}-1}{\sigma_{ec}}} \right)^{\frac{\sigma_{ec}}{\sigma_{ec}-1}}$$

- "Green factor" G assumed to be constant and normalised to 1
- s calibrated as 0.16, σ_{ec} parameterized as 0.2

back

Calibration - Consumption and production shares

Households:

- Household consumption shares: Enquête Budget de famille, 2017
- Distributing consumption expenses between non-durables and durables
- Share of dirty durables among durables from share of dirty energy consumption within energy consumption, from Energy Supply and Use tables (PEFA, Eurostat, 2014)

Production:

- Dirty and clean capital: sectoral capital weighted by sectoral shares of dirty and clean energy use, and aggregated (source: PEFA 2014 and WIOD 2014)
- Same for labour
- Same for electricity production separated between clean and dirty, with dirty electricity production then merged into dirty production

Calibration - Elasticities

- Very difficult to calibrate elasticities related to clean/dirty goods
- We now have the substitution elasticity of substitution...
  - between durables and non-durables in consumption set to 0.9
  - between clean and dirty bundles in production set to 10
  - between clean and dirty durables bundles in consumption set to 10
  - between capital and energy in production set to 0.3
  - between durables and energy in consumption set to 0.3
  - between clean electricity capital and land set to 0.2