On the way to net zero. But which way?

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Roadmap of the presentation I

Introduction

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- Damages increase with warming (probably in a convex way)
- Carbon neutrality necessary to stabilize temperatures (and damages):
  - EU + USA: 2050
  - China: 2060
  - India: 2070
- But net zero date not enough: need to look at the transition period
- To help guide policies and agents, intermediary steps: in the EU, *Fit for 55* + discussion about a 90% reduction in 2040
- But initial goal remains: cap warming to 2°C, and if possible 1.5°C (COP 2015)

Research question How do the optimal trajectories associated with these different climate objectives differ ?

⇒ **What we do**: model of French economy provides optimal pace of replacement of brown capital by green one, and the macroeconomic consequences, under these climate objectives

Model

Model

- A single productive sector, using as inputs: brown capital (emits GHG), green capital (no GHG), and constant L :

$F(K^b_{t-1}, K^v_{t-1}, L)$

- A social planner maximises intertemporal utility, under different climate objectives:
  - targets on emissions flows : $e_t \leq \underline{e}_t$
  - cap cumulated emissions until carbon neutrality : $\sum_{t=2023}^{2050} e_t \leq E_{\max}$
- focus on the impact of transition choices: damage not modeled.
- calibration:
  - France
  - brown capital $=$ 55% of total capital
  - residual brown capital, linked to carbon sink $(35MtCO_2eq)$

Related literature :

- Rozenberg et al. (2020). focus on policy instruments (decentralized equilibrium)
- Acemoglu et al. (2012). endogeneous productivity
- Pisani-Ferry and Mahfouz (2023), I4CE (2022), 3ME, IMACLIM-R-France. macroeconomics of the transition and investment needs

Results

Result #1 The more ambitious the climate policy, the earlier the transition

ZEN is late, *Fit for 55* brownier after 2030, 2040 target solves that issue

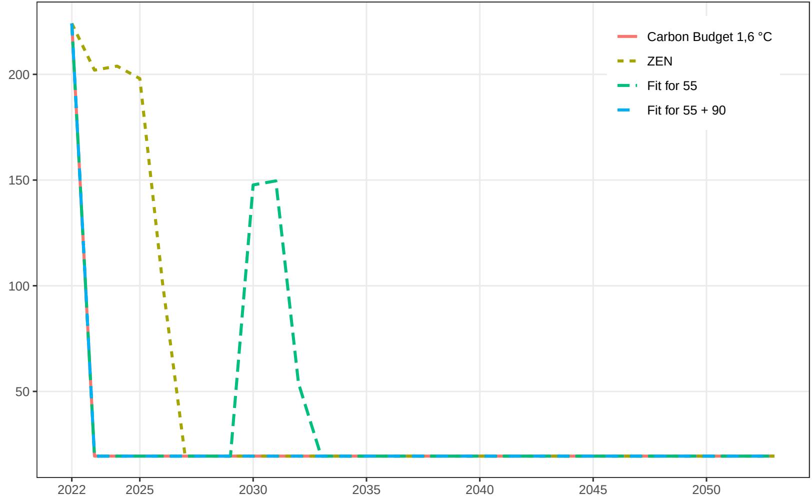

Figure 1: Brown investment (bn€)

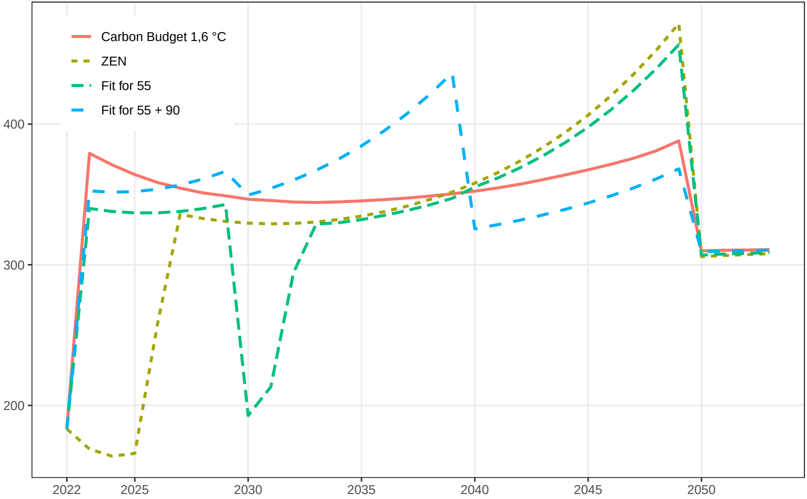

Figure 2: Green investment (bn€)

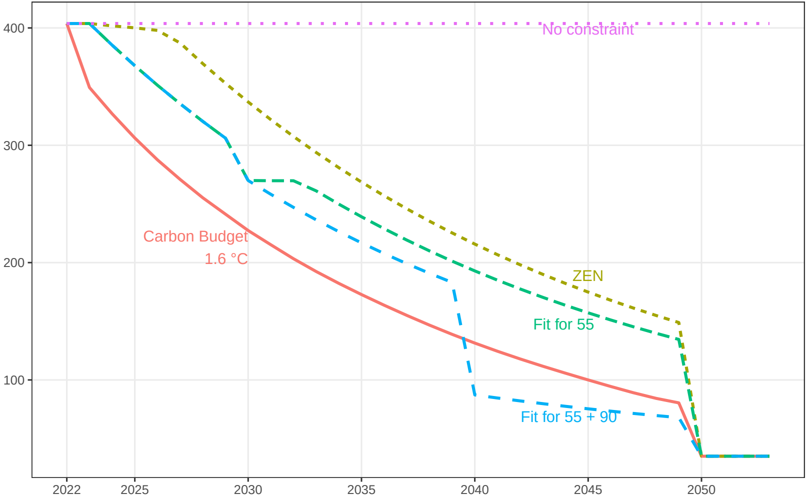

Figure 3: Carbon emissions ($MtCO_2eq$)

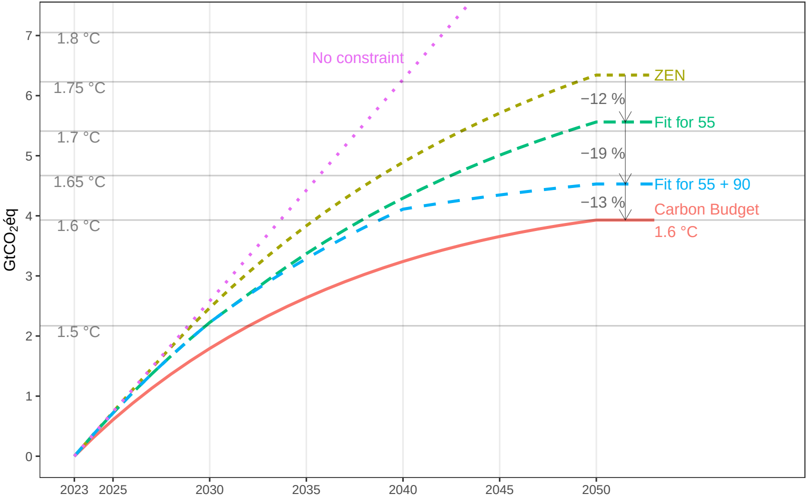

Figure 4: Cumulated carbon emissions ($GtCO_2eq$)

Result #2 Complying with a given carbon budget is the least costly way to cap cumulated emissions

By construction, maximizes well-being while respecting the limit set on cumulative emissions.

Result #3 Never strand early with specific flow targets

With targets on the emissions flows for specific years, the stranding of brown capital happens only at the target date, never before.

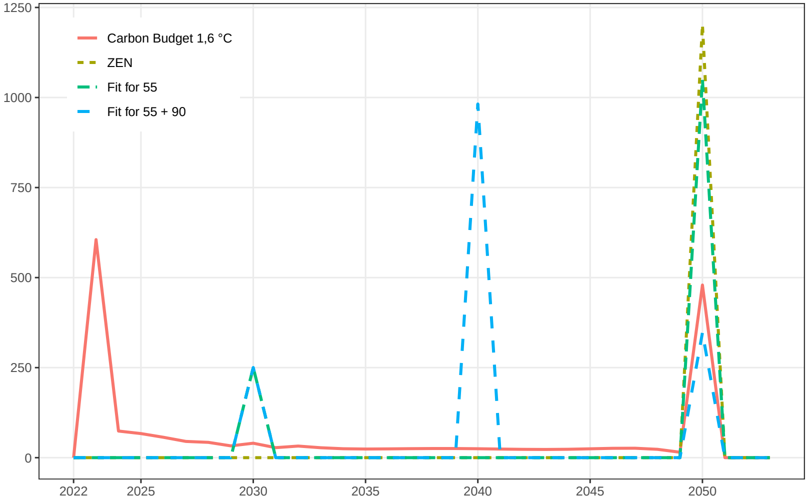

Figure 5: Stranding of brown capital (bn€)

Result #4 Regular targets to get closer to the Carbon Budget trajectory

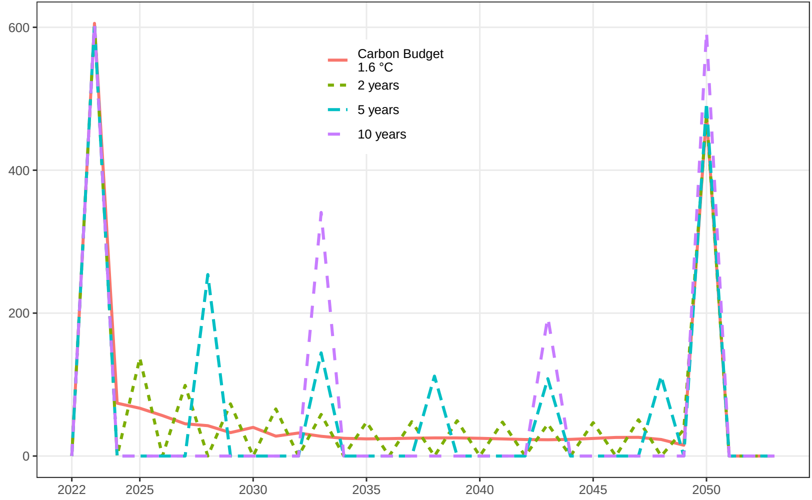

Figure 6: Stranding of brown capital (bn€)

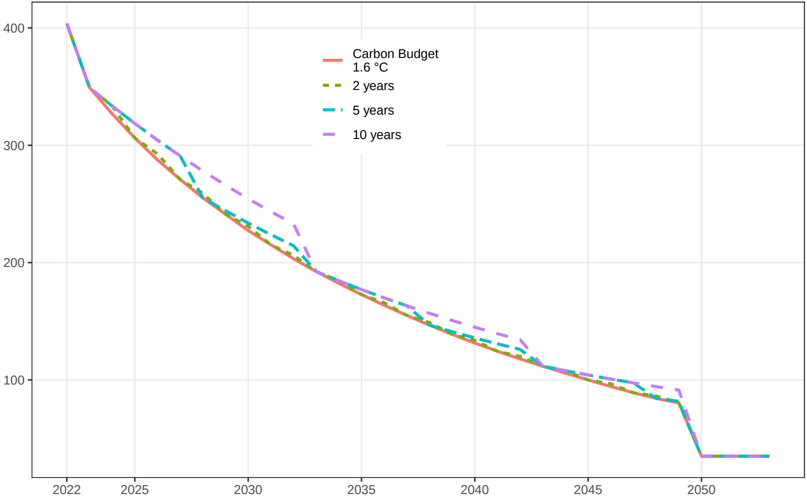

Figure 7: Carbon emissions ($MtCO_2eq$)

Result #5 Later, stronger, harder

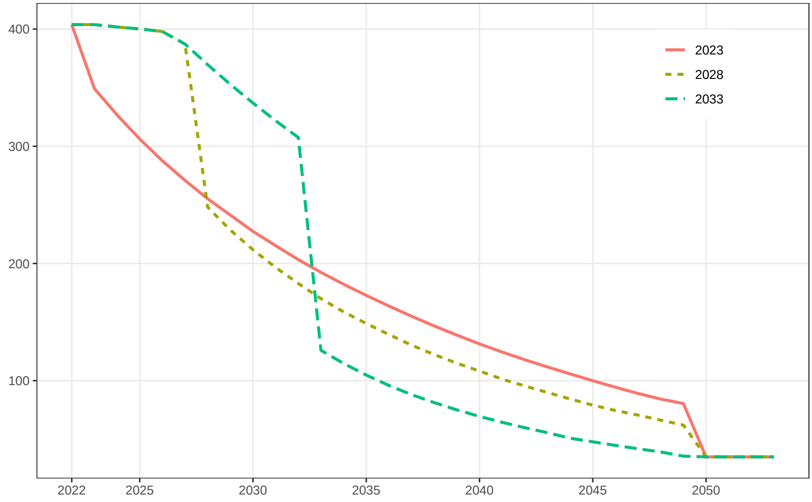

Figure 8: Carbon emissions ($MtCO_2eq$)

a later transition leads to more stranded assets

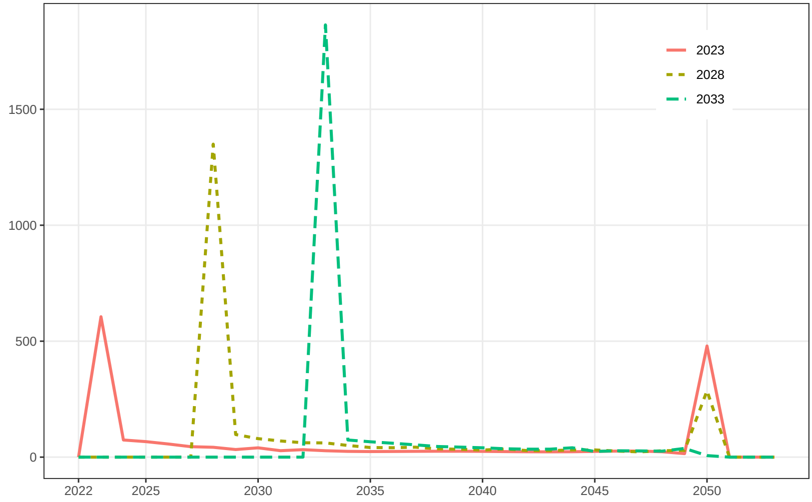

Figure 9: Stranding of brown capital (bn€)

Result #6 Less total investment with the transition

Different result from bottom-up estimates of the green investment needs

- additional costs rather than volume increase
- general equilibrium effects reducing other investments

Conclusion

Conclusion

Model provides optimal trajectories of the transition towards neutrality under different climate objectives.

Results:

1. The more ambitious the climate policy, the earlier the transition
2. Complying with a given carbon budget is the least costly way to cap cumulated emissions
3. Never strand early with specific flow targets
4. Regular targets to get closer to the Carbon Budget trajectory
5. Later, stronger, harder
6. Less total investment with the transition

But optimal trajectories. In the real world, how to implement them?

Insee working paper and **codes** are available.

Annex

Model : program of the social planner

$$\max_{\substack{\tilde{I}^b_{t_0+1},\dots,\tilde{I}^b_{T_E}\geq 0\\ \phi^b_{t_0+1},\dots,\phi^b_{T_E}\geq 0\\ I^v_{t_0+1},\dots,I^v_t,\dots\geq 0}} \sum_{t=t_0+1}^{+\infty} \frac{u(C_t)}{(1+\rho)^{t-t_0}}.$$

- Resources - Uses balance:

$$F(K^b_{t-1}-\phi^b_t, K^v_{t-1}, \bar{L}) = C_t+\tilde{I}^b_t+\delta\underline{K}^b+I^v_t.$$

- Accumulation of brown and green capital :

$$\begin{cases} K^b_t = \tilde{K}^b_t + \underline{K}^b \\ \tilde{K}^b_t = (1-\delta)(\tilde{K}^b_{t-1} - \phi^b_t) + \tilde{I}^b_t \\ K^v_t = (1-\delta)K^v_{t-1} + I^v_t \end{cases}$$

- carbon constraints :
  - $\phi_{T_E} = K^b_{T_E-1} - \underline{K}^b$, $\tilde{K}^b_t = \tilde{I}^b_t = \phi^b_t = 0$, $K^b_t = \underline{K}_b, \forall t \geq T_E$
  - $e_{t_l} \leq \bar{e}_{t_l}, \phi^b_{t_l} = \max\left(\tilde{K}^b_{t_l-1} - \frac{\bar{e}_{t_l}}{e_b}, 0\right)$
  - $\sum_{t=t_0+1}^{T_E} e_t \leq E_{\max}$