Great expectations in transition

Heterogeneous beliefs and climate policy uncertainty

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November 19, 2021

Motivation: policy commitment uncertainty

- Climate change → Decarbonisation process
  - Mitigation policies needed to change expected relative costs..
  - ..and move investments towards low-carbon technologies
- Long-term policy commitments are announced..
  - Paris Agreement on keeping temperatures below 1.5-2°C
  - EU net-zero emission target by 2050
- .. but will clear policies follow to fulfil such commitments?
  - Australia: carbon tax in 2012, repealed in 2014 after election
  - USA and Paris: in (Obama), out (Trump), back in (Biden)
  - France: a diesel tax was announced in 2018 and then removed after protests by the Gilets Jaunes movement

Transition risks drivers of policy uncertainty i

Tony Abbott (2014)

"..the repeal of the carbon tax means a $550 a year benefit for the average family"

"On energy, I will cancel job-killing restrictions on the production of American energy - including shale energy and clean coal - creating many millions of high-paying jobs"

Donald Trump (2016)

Transition risks drivers of policy uncertainty ii

- Indeed, expanding literature on how a disorderly transition to low-carbon economy might entail several transition risks, e.g.:
  - Job losses - winners and losers (Vona, 2018)
  - Stranded assets (Semieniuk et al., 2021; Campiglio and van der Ploeg, 2021)
  - Financial volatility (e.g. 'Climate Minsky moment' (Carney et al., 2019))

→ What is the impact of this uncertainty on firms' investment decisions?

Heterogeneous expectations about future climate policy

- In order to take investment decisions, firms form expectations about future costs and therefore about future climate policy
- Models studying the impact of climate policy uncertainty often assume rational expectations (e.g. van der Ploeg and Rezai, 2020)
- However, there is extensive empirical evidence that agents' expectations are not rational and are heterogeneous (e.g. Hommes, 2011; Assenza et al., 2014)
- In particular, Barradale, 2014 finds heterogeneous beliefs of energy professionals about future climate policy

→ We incorporate the heterogeneous expectations framework (Brock and Hommes, 1997, 1998) into a model of investment allocation and climate policy

Research objectives

- Research objectives:
  - Understand the dynamic interaction between investment allocation, climate policy and heterogeneous beliefs
  - Assess the ability of the policy-maker to balance between climate policy commitment and transition risks
- Preliminary results:
  - Firms' beliefs about climate policy might delay transition, even in the presence of full policy commitment
  - Policy-maker's commitment to climate policy influences beliefs and thus transition
  - Delaying climate policy increases the transition risks involved to the point that the transition might fail
  - Continuously revising downward the climate policy target significantly delays or impedes the transition

Structure of the model

- Two technologies ($i = l, h$)
  - Incumbent technology h based on fossil fuel use and emitting GHG, less expensive
  - Niche low-carbon technology l (renewables, hydrogen, etc.), more expensive
- Policy-maker announces a schedule for carbon tax rate τ, but actual tax rate can deviate from the target depending on:
  - The policy-maker commitment
  - The transition risks potentially involved with imposing the tax
- Firms have heterogeneous beliefs about future carbon tax ($j = b, s$)
  - Believers in climate policy commitment (b)
  - Skeptics in climate policy commitment (s)

  $\rightarrow$ switching between beliefs depend on their relative accuracy

Investment allocation I

- Firms invest to expand productive capacity
- Investment allocation between the two technologies depends on their discounted sum of expected future costs

$$E^j_{t-1}(\Theta_{it}) = \sum_{r=t+1}^{T} \rho^r \theta_{ir}(1 + E^j_t(\tau_{ir})) \quad (1)$$

where

- ρ: discount rate
- θ_{ir}: cost of capital i, exogenous and constant, $\theta_{lr} > \theta_{hr}$
- $E^j_t(\tau_{ir})$: expected tax (only on high-carbon technology) $\rightarrow$ we assume heterogeneous beliefs j

Investment allocation II

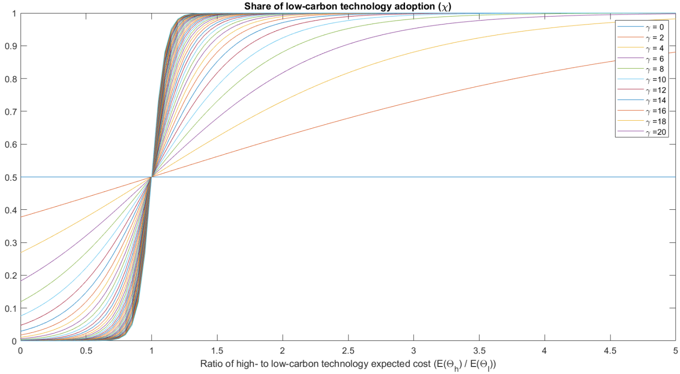
→ The low-carbon share of investment of type j:

$$\chi_t^j = \frac{\exp(-\gamma E_{t-1}^j(\Theta_{lt}))}{\sum_i \exp(-\gamma E_{t-1}^j(\Theta_{it}))} \tag{2}$$

where:

- χ_t^j: share of low-carbon investment for type j
- $E_{t-1}^j(\Theta_{lt})$: expected future discounted costs of low-carbon capital
- γ: intensity of choice

Intensity of choice parameter



Beliefs on carbon tax

- Firms have heterogeneous beliefs about the future tax:
  - Believers in climate policy commitment (b):

$$\begin{aligned} E_t^b(\tau_r) &= \tau_r^T \\ &= \tau_0(1+g_\tau^T)^r \end{aligned} \tag{3}$$

    where g_τ^T is the growth rate of tax target
  - Skeptics in climate policy commitment (s):

$$E_t^s(\tau_r) = \tau_0(1+g_\tau^s)^r \tag{4}$$

    where g_τ^s is the tax growth rate expected by the skeptics with

$$g_\tau^s < g_\tau^T$$

Belief switching

- Agents can switch belief over time. The share of belief j is given by:

$$n_t^j = \frac{exp(-\beta U_{t-1}^j)}{\sum_j exp(-\beta U_{t-1}^j)}, \tag{5}$$

where

- β: intensity of choice
- U_t^j: relative performance of expectation rule j, i.e.

$$U_t^j = \eta(E_{t-1}^j(\tau_t) - \tau_t)^2 + (1-\eta)U_{t-1}^j \tag{6}$$

η: memory parameter

Low-carbon investment and capital share

- The low-carbon investment share for the overall economy, χ_t, is thus given by:

$$\chi_t = n_t^b \chi_t^b + n_t^s \chi_t^s \tag{7}$$

- The low-carbon capital evolves as:

$$K_t^l = K_{t-1}^l (1 - \delta) + I_t \chi_t \tag{8}$$

→ Low-carbon capital share:

$$\kappa_t = \frac{K_t^l}{\sum_i K_t^i} \tag{9}$$

Climate policy

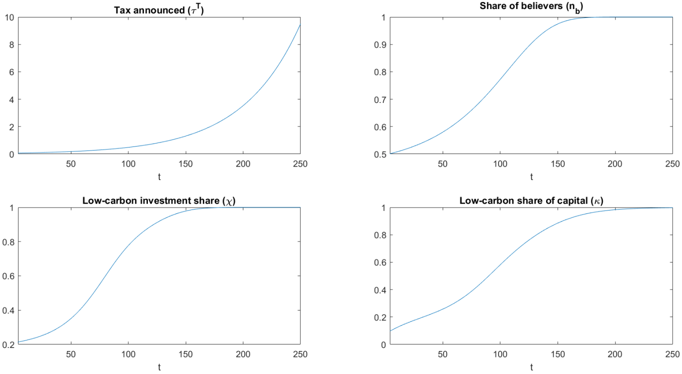
- Policy-maker, at the beginning of the simulation, announces τ^T, i.e. the tax target for following periods:

$$\tau_t^T = \tau_0(1 + g_\tau^T)^t$$

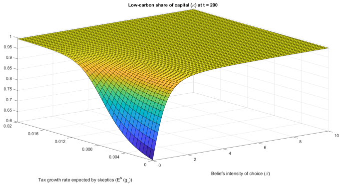
where

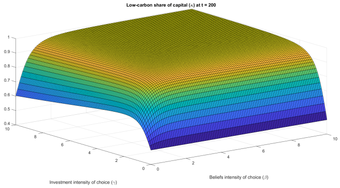
  - g_τ^T: growth rate of tax target

Benchmark scenario



Intensity of choice and degree of belief heterogeneity





→ High heterogeneity of beliefs and low firms' intensity of choice (β, γ) might delay transition even with full climate policy commitment

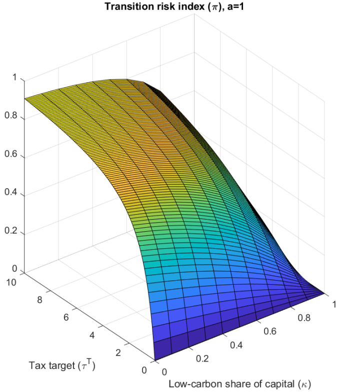
Transition risks involved with climate policy I

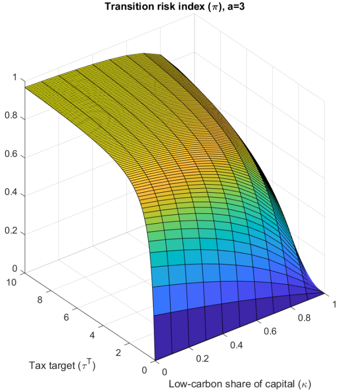
- In every t, policy-maker computes a transition risk index (π) associated with the tax target
- π depends on the share of high-carbon capital and on the tax rate:

$$\pi_t = 1 - \frac{1}{1 + a\,(1-\kappa_t)\,\tau_t^T}, \tag{10}$$

- where
  - $(1-\kappa_t)$ is the high-carbon sector share
  - a is a parameter indicating how π is affected by high-carbon sector share and tax target

Transition risk index π





Policy maker commitment

- Based on π_t, the policy-maker might decide to lower the actual tax in t:

$$\tau_t = c\tau_t^T + (1-c)\tau_t^T(1-\pi_t), \tag{11}$$

where

  - $c \in [0,1]$ indicates the policy maker commitment to climate objectives ($c=1$) or to the reduction of transition risks ($c=0$)

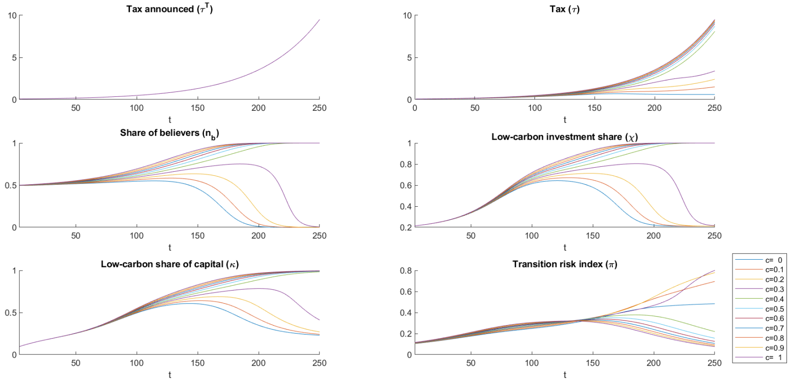
- We consider two types of tax target in the presence of transition risks:
  - Fixed tax target:

$$\tau_{0,r}^T = \tau_0(1+g_\tau^T)^r$$

  - Dynamic tax target:

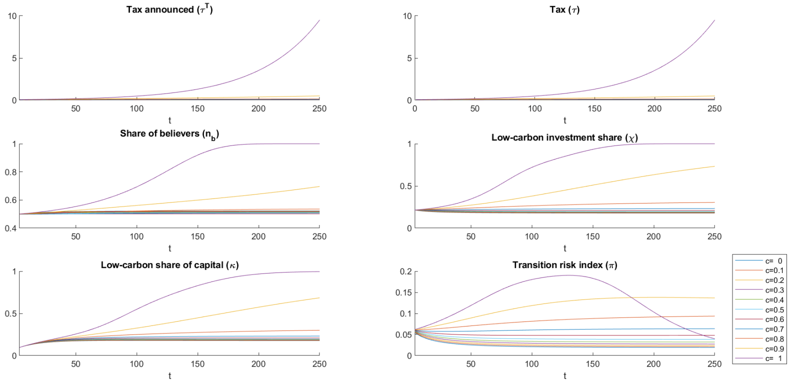
$$\tau_{t,r}^T = \tau_{t-1}(1+g_\tau^T)^r$$

Fixed tax target



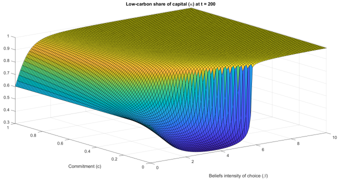
- When the policy-maker aims at reducing the transition risks, the transition is delayed causing an increase in π which eventually prevents the transition

Dynamic tax target

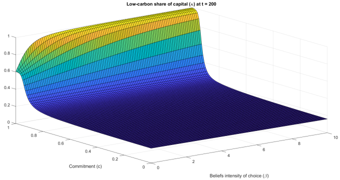


- A continuous revision of targets appears to be self-defeating under $c \neq 1$

Time to transition



(a) Fixed tax target



(b) Dynamic tax target

- (a) Low commitment delays or impedes the transition depending on β because delayed action implies higher transition risks in the future
- (b) Very high commitment and higher g_τ are necessary for the transition to happen

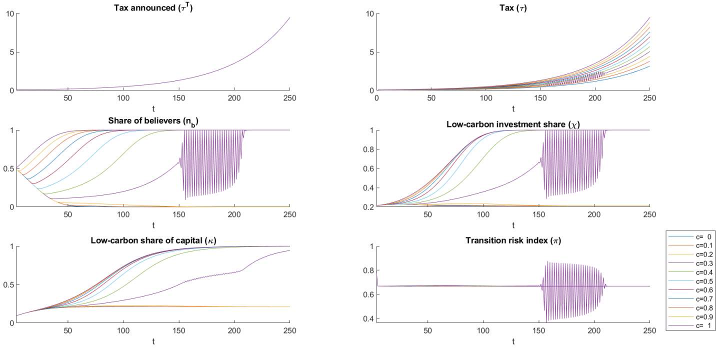
Transition risks depending on transition intensity I

- We also consider a transition risk index depending on the transition intensity

$$\pi_t = 1 - \frac{1}{1 + a\ tr_t} \tag{12}$$

- where $tr_t = \frac{\chi_t}{\chi_{t-1}}$, i.e. the ratio of the low-carbon investment share in t and the low-carbon investment share in $t-1$

Transition risks depending on transition intensity II



→ Depending on c and β, the transition might be characterised by the emergence of cycles

Preliminary conclusions

- Policy uncertainty and heterogeneity of beliefs might delay transition even in the absence of transition risks
- A policy-maker willing to minimise transition risks (low commitment to climate objectives) might delay climate policy, increasing future transition risks and preventing the green transition
- Continuously revising climate objectives significantly hampers the transition
- The dynamic interaction between climate policy, beliefs and transition costs might imply the emergence of cyclical behaviour in the system

Thank you!

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 853050 - SMOOTH)

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